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ABSTRACT

This book presents the life stories of 10 women who work in various fields of science as well as information on education and financial aid and getting a good job (focusing on jobs in academia and industry). The life stories, based on interviews with women scientists, are organized according to their academic fields: (1) biology--Dr. Beatrice Sweeney (botanist), Dr. Rita Colwell (microbiologist), and Dr. Jennie Tou (virologist); (2) Chemistry--Dr. Sandra Greer (physical chemist); (3) geology--Dr. Helen McCammon (ecologist); (4) astronomy--Dr. Vera Rubin (astronomer); (5) physics--Dr. Eugenie Mielczarek (physicist), Dr. Evans Hayward (nuclear physicist); (6) mathematics--Dr. Joan Rosenblatt (statistician); and (7) computer science--Karen Thomann (computer programmer). Each section begins with a brief description of the field and comments on career opportunities for women. Associations and committees related to furthering opportunities and career goals for women in science are included in an appendix. Purpose, current address, contact person, and when applicable, membership and dues information are included. (JN)

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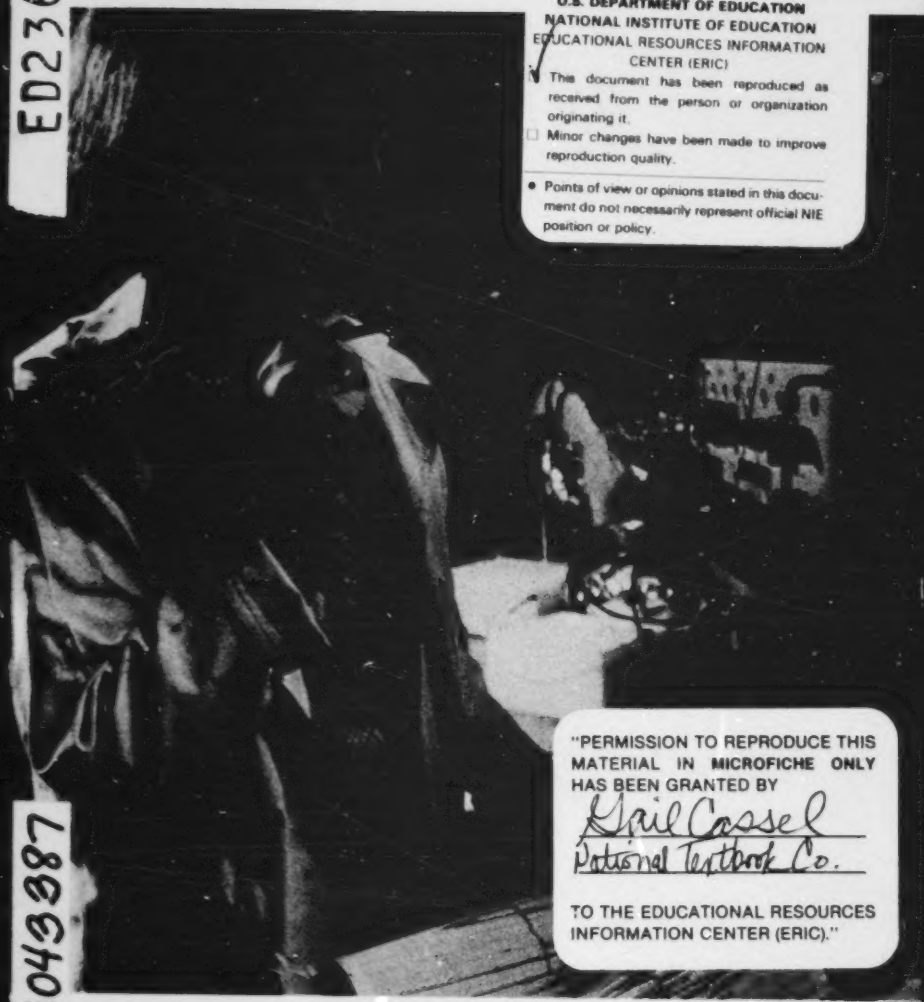

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Alice Fins

WOMEN IN SCIENCE

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ABOUT THE AUTHOR

Alice Fins is a free-lance writer-editor who has always promoted the rights of women in professional employment.

She began her professional career as an English teacher in upstate New York. She taught grades seven through twelve in a rural Wisconsin community and later in a suburb of Milwaukee, and also in the adult education program of a vocational college in Milwaukee.

After six years of teaching she made a career change to writer-editor. She wrote a weekly newsletter, *Consumerism*, for the Commerce Clearing House in Chicago.

When she moved to Washington, D.C., she became editor of *Guidepost*, the newspaper of the American Personnel and Guidance Association. In this position she kept up-to-date with current trends in education and employment of women.

After she left the APGA to work as staff director for information of the American Bar Association's Government Relations Office, she continued to be interested in women's employment problems. Ms. Fins worked at the ABA until her daughter was born.

At that point, she decided to work on a free-lance basis because it gave her the flexibility she needed while caring for her daughter.

As a free-lance writer-editor she has served as a consultant to the U.S. Office of Education on cooperative education and to reports on women in vocational education, women and careers, and ethnic women. She is currently analyzing statistical tabulations to write a report on the "Characteristics of Students in Noncollegiate Postsecondary Occupational

Schools" that will be issued by the National Center for Education Statistics.

She is the author of two other recent VGM Career Horizons titles: *Women in Communications* and *Opportunities in Paralegal Careers*.

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INTRODUCTION

Why a book on women in science?

There are few women scientists. However, more women are capable of becoming scientists and should consider science as a realistic option.

Dr. Rita R. Colwell, a microbiologist whose own story is told in Chapter 1, encourages young women to enter the fields of science. "There is plenty of opportunity," she said, "and we need all the brilliant people we can get."

This book presents the life stories of ten women who work in various fields of science. All of them, like Dr. Colwell, believe that more women scientists are needed.

Each chapter is based on interviews with these women scientists. All of them are exciting people who lead busy and rewarding lives. After leaving each interview, the author had a heady feeling—a non-chemical high—sparked by her conversations with such dynamic women.

These women generously shared their experiences in the hope that their stories would encourage other women to pursue careers in science. All of the women portrayed in this book are married, and most of them are raising or have raised children. All of them faced various kinds of discrimination in their professional lives. Yet, each continued to pursue her career.

Today, as in the past, women do not generally see themselves in science careers. Women are often conditioned to believe they cannot succeed in the world of science because they don't think logically or analytically. Textbooks and television rarely portray women as scientists. Yet, against all odds, a good number of women are scientists. Many of them,

in fact, are in the forefront of their fields. You will meet several outstanding women scientists in this book.

Women have traditionally had three professional fields open to them: education, nursing, and secretarial work. Outside of these fields, women have faced special problems including parental opposition to entering traditionally male fields, fears of being perceived as unfeminine and thus undesirable as a wife, and discrimination within a particular field itself. The thing to remember, however, is that none of these problems is insurmountable to the woman intent on establishing herself in a science career. Each of the women interviewed in this book is living proof of this fact.

Of course, this does not mean that women wishing to enter science professionally don't face many obstacles in pursuing their careers. Educational discrimination, particularly in high school, can virtually snuff out a promising career before it begins. Again, persistence is the key. According to Deborah David in her report, *Career Patterns and Values: A Study of Men and Women in Science and Engineering:*

> Women with the tenacity to pursue their career interests by insisting on taking math and science in high school, remaining in academic programs and not being shunted into a commercial or general curriculum, will succeed in entering college as potential science or engineering majors.

Other researchers have substantiated Ms. David's contention that many women naturally inclined toward the sciences don't become scientists because they are discouraged from taking the necessary high school math courses. For all intents and purposes, a person interested in the sciences must have at

least two and a half, and preferably three or more years of high school math. Such study should include two years of algebra, one year of geometry, and one year of precalculus—usually trigonometry and statistical analysis. Also highly recommended are courses in probability and computer programming.

One researcher pointed out another problem unique to women scientists; namely, that nearly all of the people in control of science education and funding are men. Consider, for example, that most science teachers, school administrators, and decision-makers in grant-giving agencies are men. Also, most editors of scientific journals are men, as are those who award prizes to scientific research projects. There are exceptions, of course—some of them, women you will meet later in this book—but generally speaking they are few and far between.

The personal qualities most necessary to a science career are motivation, competitiveness, and assertiveness. While intrinsically speaking, women are as motivated as men, many women are conditioned to subordinate their interests to those of their husbands or children. Most of the women whose stories are included here succeeded in their careers, their marriages, and in bringing up healthy, well-adjusted children.

Women, generally, are not as competitive as men. Many women scientists, including many in this work, have admitted that they do not enjoy competition and controversy. They have, nonetheless, succeeded in becoming scientists.

Aggressiveness has traditionally been seen as a male domain. Women were thought to be passive. However, as Dr. Estelle Ramey, a noted physiologist, said, "A young woman

should be pushed to ask questions at national meetings, to give her name loud and clear, and to comment on work in her own field." In other words, women have to blow their own horns.

Practically all the women in this book agree with Dr. Ramey that, "it takes a lot more than hard work and ability if you are a woman in science."

"Potential scientists, both female and male, need persistence. You have to love science. You must like the excitement of discovery. You must be willing to do a lot of hard work. If you are hedonistic and live for the moment, science is not for you. You cannot go into science because you expect to get a good job out of it when your training is completed," Dr. Rita Colwell, a successful microbiologist, explained.

Young women who later become scientists share certain traits. These include an interest in puzzles and problem solving and a desire to take things apart to see how they work. One minority woman scientist reported taking apart a doll as a child because she was more interested in the mechanical crying device inside than in playing mother.

Young women destined to become scientists also had two other common traits that appeared early: They wanted to do things that would improve society, and they wanted to do things independently of others.

Judy Rosenbaum Franz, a professor of physics at Indiana University, explained how she was able to cope with the pressures: "My parents, both of whom are chemists, were always extremely encouraging. The fact that my mother is a scientist helped me through some difficult times in the late Fifties and early Sixties when people asked repeatedly: 'But don't you think physics is unfeminine?'

"My husband has always been totally encouraging. If this were not the case either I wouldn't be a physicist or I wouldn't still be married," Dr. Franz added.

"Women in science need all the encouragement they can get and more. If the understanding and encouraging parents, husband, and thesis advisor are not there, a close group of friends who will provide psychological support is essential, Dr. Franz believes. "It is a terribly exciting and rewarding life, but not an easy one," Dr. Franz concluded.

CHAPTER 1

BIOLOGY

Biology is the branch of science that deals with living organisms and vital processes. So it is the biologist who, in pursuit of the study of life, comes into contact with so many of the most urgent social issues of our times, including aging, overcrowding, disease, food supply, air and water pollution, waste disposal, space travel, and population control.

Because of the many types of living organisms and the various ways of studying them, many biologists specialize in one of the biological sciences. For example, botantists study plants, microbiologists study microscopic organisms, zoologists study animals, ecologists study the relationship of organisms to the environment, geneticists study the mechanisms and consequences of inheritance, and physiologists study the mechanisms and functions in cells, organs, and whole organisms. Moreover, each of these areas has its own specialities as well.

Biology is often a component of many other careers, such as medicine, dentistry, occupational and physical therapy, and other laboratory technologies. Agronomists, horticulturists, and other agricultural scientists look to biologists for answers to plant-related problems. Social scientists such as anthropologists and psychologists often call on biologists to supply answers to questions puzzling them. Related interdisciplinary careers such as psychobiology are also on the increase.

A publication of the American Institute of Biological Sciences, *Careers in Biology,* reports that, "nearly 40 percent

of all biologists work in medical, agricultural, and space activities, in large industrial laboratories or small private laboratories, government research institutions or stations. Other work environments may be forests, national parks, state and municipal public utility facilities, agricultural sites, oceanographic vessels, museums and zoos."

As in all other fields, what you do in biology depends on your background and training. A high school graduate may work as a greenhouse aid, laboratory assistant, or laboratory animal technician.

Demand is increasing for bio-technicians. These jobs require a high school education or more, supplemented with on-the-job training. Some positions require training in a two-year college or technical school. Specialized technical positions such as medical technologists now require either a Bachelor's or Master's degree.

Increasingly, most biological positions require at least a Master's degree. Since the field is overcrowded, employers are insisting on higher standards for employees and often require a Ph.D. when lower degrees were required previously.

Women in the biological sciences have made certain gains. They are earning an increasing percentage of the degrees awarded in nearly all biological specialties. In 1976 women earned about one-third of the Bachelor's degrees and one-fourth of the Ph.D.'s awarded in biology. Substantial numbers of women are found in the lower ranks of most biology department faculties. The percentage of women consultants on review panels, committees, and councils has increased significantly since 1971 and more women in the biological sciences are applying for and receiving research grants.

Salaries for women in all areas of the biological sciences, however, lag behind those of men. Few women are found in the top decision-making positions, and fewer still receive the accolades—professional honors and awards.

According to the U.S. Commission on Civil Rights, in 1979 over 200 women complained officially of sex discrimination at the National Institutes of Health (NIH) in Bethesda, Maryland. One of these women won a law suit against NIH, and was subsequently granted a retroactive pay raise. All the women charged that 99 percent of those who received promotions were men and that out of 184 top level (supergrade) positions at NIH, only fourteen were held by women.

This situation is improving though, as women have recently been elected to the presidencies of a number of professional biological societies, including the American Institute for Biological Sciences, (see the story of Dr. Beatrice Sweeney, which follows), the American Physiological Society, the American Society for Biological Chemistry, the American Society for Cell Biology, and the American Society for Microbiology.

There are more women in the biological sciences than in any other area of science. A report by Elizabeth M. O'Hern provides the following estimates of women in the various specialties of the biological sciences.

In 1976, women comprised 23 percent of all biological scientists. The distribution of women in each of the specialty areas was: 22 percent in botany, 31 percent in genetics, 17 percent in zoology, 16 percent in biophysics, 19 percent in animal physiology, 23 percent in plant physiology, and 29 percent in molecular biology.

One of the most rapidly developing biological sciences is

microbiology. There are over 30,000 microbiologists working today, and over one-quarter of them are women.

"Microbiology is an excellent area for women who wish to succeed. There is less prejudice against women in this discipline than in engineering or physics where the machismo ethic seems to operate rather overtly," said Dr. Rita Colwell, whose story appears in this chapter.

"Microbiology requires cooperation in the laboratory. It is a very human-oriented discipline involving aspects of public health such as understanding and controlling infectious disease, alteration of the environment, and food processing," Dr. Colwell continued.

Most of the areas of microbiology are growing. Microbiologists are now involved in activities as different as the study of gene structure, beer and cheese production, and industrial processes based on the phenomenal ability of microorganisms to decompose and synthesize complex organic molecules. Most of the Nobel prizes given in the life sciences in recent years have been awarded to microbiologists studying the mechanisms of metabolism and heredity.

"While, in general, science careers in industry often may not involve basic research or not as much of it as in universities, this is not the case in microbiology. Basic research in microbiology is being done in many industrial laboratories. Some of these studies include work on potential anticancer agents such as interferon, or on nutrition supplements and synthetic foods, as well as work in health care areas," Dr. Colwell said.

There are a variety of types of microbiology. Specialization in any of them takes place during graduate training in college

or on the job. If you get a background in biology and take courses in microbiology you can then specialize in a particular field at a later date.

These specialty fields include medical and clinical microbiology, public health and environmental microbiology, immunology, virology, and others.

Medical and clinical microbiology deals with the search for the pathogens that cause disease. Some of these microbiologists work in the field studying diseases in their natural habitats, while others work in hospitals and public health laboratories.

Public health and environmental microbiologists attempt to control communicable diseases and other health hazards in the community. They do this by isolation and identification of microorganisms in specimens from patients and in water or food supplies. Environmental microbiologists are involved in testing water in lakes and streams for biological and chemical pollutants and in inspecting food and water in processing plants. They try to control the spread of pathological agents by insects, vermin, and wildlife.

Immunologists develop vaccines to protect people against diseases. Women hold 33 percent of the Ph.D.'s in this field. Immunology is one of the fastest growing fields in science. For example, an immunological reaction is used as a simple test for pregnancy.

Virologists study viruses. Some virologists are involved in cancer research. Others are developing viruses to replace pesticides as a means of controlling insects. (See the story of Jennie Tou, who now works in this field.)

Other areas of microbiology are also growing and provide

equally exciting opportunities. They involve the conjunction of microbiology and another field; for example: microbial physiology and biochemistry, microbial genetics, molecular microbiology, protozoology, agricultural and plant microbiology, industrial microbiology, aquatic microbiology, food microbiology, and space microbiology.

"At present, the continued expansion of American industry, greater demands for improved medical care, and increased dependence on the products of basic research all provide more positions for microbiologists. Experience over the last several decades suggests that opportunities will likely continue to be available," claims the American Society for Microbiology.

Which areas of microbiology will be in greatest demand in the future is difficult to predict. Health, food, environment, energy, and industrial processes would seem to be areas of greatest concern for the remainder of this century. Microbiology is involved in all of these, often in multiple ways. There should be a promising future for any student who is willing and able to become well-trained.

"In addition, the broad training that a microbiologist receives in the basic sciences opens opportunities for employment in related fields," according to *Microbiology in Your Future*, by the American Society for Microbiology. This society, located at 1913 I St., N.W., Washington, D.C. 20006, publishes a *Directory of Colleges and Universities* offering degree programs in microbiology.

University of California

DR. BEATRICE SWEENEY

Botanist

Dr. Beatrice Sweeney, the incoming president of the American Institute of Biological Sciences said, "I have wanted to work with plants in some way since before I was six years old. Originally I drew and photographed flowers and planned to become an artist. I was not exposed to science in high school at all. I did, however, learn the names of many eastern plants on my own.

"My first botany course was as a freshman at Smith College, and from that time on I devoted my efforts to learning

how plants work (i.e., plant physiology). I was lucky in first being able to take special honors courses at Smith College and so devote more time to research as an undergraduate.

"Later, I was accepted as a graduate student by Dr. Kenneth Thimann at Harvard. Dr. Thimann even then was very receptive to female students and their needs. He allowed me to come to the lab when I could after I had my first baby, so that I was not forced to give up graduate school. It is interesting that many of Dr. Thimann's women graduate students have succeeded in their professions, and occupy university positions all over the country.

"Now I am a full professor of biology at the University of California, Santa Barbara, which I like very much. I have my own lab and a number of graduate students. I am also busy with teaching, especially in the College of Creative Studies, a college for the intellectually gifted. I enjoy working with these alert and bright young people.

"My professional progress has not been without difficulties. For a long time, I felt that I could only work half-time, since I wanted to be able to devote some time to my four children as they were growing up. One of my ideas when I was at college and considering biology as a career was that women should not have to give up having children if they wanted to be scientists, since this was not required of men. At the time that I was young, most of my women teachers were single. I did not wish to give up marriage and a family, nor did I want to give up science. Because I worked only half-time, regular university positions were closed to me. Thus I was a lecturer and research scientist for many years.

"When my children were grown, I wished to become a regular professor since I could work full-time. But, with the number of publications that I had written, no one would hire me as an assistant professor. Since I had only limited experience as a teacher, they wouldn't hire me as an associate professor (with tenure) either. Luckily, I was able to be at Santa Barbara before 1970, when teaching positions became very difficult to find."

After earning her Ph.D., Dr. Sweeney served a post-doctoral fellowship at the Mayo Foundation in Rochester, Minnesota. After this she worked first as junior research biologist, then assistant, and finally associate research biologist.

In 1960, she went on a National Science Foundation Expedition to North Australia to study the photosynthesis of marine tropical algae.

For seven years she was an associate research biologist at Yale University. For the next six years she was a lecturer at Yale, teaching courses in algae physiology and giving lectures in sophomore courses on the diversity of organisms. During this time Dr. Sweeney also traveled to Oyster Bay, Jamaica, on a National Science Foundation expedition to study the bioluminescent dinoflagellate, *Pyrodinium bahamense.*

After this, Dr. Sweeney began her career at the University of California, Santa Barbara, as a lecturer in the Department of Biological Sciences, teaching courses in algal physiology and plant development. In 1969 she went on a scientific "Alpha Helix" expedition to New Guinea to study bioluminescence. In 1971, after serving four years as an associate profes-

sor, Dr. Sweeney was awarded a full professorship. And then in 1975, she again took part in a bioluminescence expedition; this time to Southeast Asia.

Dr. Sweeney is interested in a variety of scientific areas including biological rhythms and space biology. She has held office in or been a member of many professional societies. In addition, she has served on the Smithsonian Institution Awards Advisory Committee.

In conclusion, Dr. Sweeney had this advice to offer young scientists-to-be: "My only advice to young women considering science as a career is to persist through all discouragements. They will be glad they did when their families are grown and have left home."

DR. RITA COLWELL

Microbiologist

"I am one of the luckiest people in the world because I am doing what I love," said Dr. Rita R. Colwell. Dr. Colwell is a microbiologist who wears several different hats: she is a researcher, a teacher, a director of the Sea Grant Program at the University of Maryland, a prolific writer of technical articles, an active participant in scientific and professional committees, a wife, a mother, and, with her husband, a sailor competing in championship regattas.

"The days go by so fast. I am frustrated because there isn't time to do everything I want to do," Dr. Colwell said.

Dr. Colwell's research interests are in marine and estuarine microbial ecology, computer applications in biology and medicine, temperature and high pressure effects on marine bacteria, and microbial systematics.

To describe her research she has written or edited seven books, made a movie which won the CINE Golden Eagle Award as one of the five outstanding science documentaries of 1976, written over 250 published papers and articles, plus a dozen others ready to be submitted; all this in addition to numerous reviews, reports, and abstracts. She has also had over sixty-three grants or contracts awarded to her.

Despite such an impressive research background, she also enjoys her work in helping guide young scientists. "Within the university one can help guide the lives of bright young people. This is very satisfying. I am very proud that just yesterday two of my best students received prestigious National Science Foundation predoctoral fellowships. Also, two students completing their Ph.D. degress received prestigious awards. One student was awarded a National Research Council postdoctoral fellowship and the other a National Institutes of Health postdoctoral fellowship. It is also a great joy to see students developing from hesitant, unsure workers in the laboratory to excited, capable, and contributing scientists. That is very rewarding," she said.

To ensure that she keeps in touch with students, Dr. Colwell teaches at least one undergraduate level course in microbial systematics and an upper-level course in marine microbiology each year. She likes lecturing but admits that, because of her schedule, she frequently has to delegate lectures to others.

As director of the Sea Grant Program at the University of Maryland she said, "I think the Sea Grant program is very exciting because it is a unique opportunity to do basic research and, at the same time, to obtain results that have immediate application, are of economic significance, or may possess great potential value."

She explained how the program operates: "Scientific inquiry supported by the Sea Grant program includes those factors governing the estuarine ecosystem, while the projects are simultaneously directed toward seeking solutions for the specific problems of the Chesapeake Bay." Some of these problems involve protecting and enhancing the resources of the Bay, including harvests of fish and shellfish, improving water quality, and studying the effects of chemical wastes and materials discharged into the Bay.

Information that Dr. Colwell and the Sea Grant researchers discover should help people who work on, or live near, the Bay, including watermen and women, seafood processors, marine operators, and others. Some of their basic and applied research may be useful to resource managers, as well as ecologists.

Donning yet another of her many hats, Dr. Colwell has also served on numerous committees and commissions. In the past, she said, she was probably chosen as the token woman. "Yet, I accepted the appointments because I believed that, in the long run, I could help other women be asked to serve on such committees, as well as provide visibility for women scientists. Things are not so blatant now. At the last meeting of the United States National Committee of the International Union of Biological Sciences, there were five women nominated out of about fifteen. Of these, three were voted in. I did not have

to say anything. They were selected on merit. This proves that things are changing."

Dr. Colwell has been active in professional organizations, serving on the editorial board of the *Canadian Journal of Microbiology, Applied and Environmental Microbiology, Microbial Ecology,* and other microbiological journals. She is also active in various committees of the International Association of Microbiological Societies (IAMS), and the American Society for Microbiology, for which she served as president of the Washington branch in 1972–1973. Currently, she is the vice chairman of the Bacteriology Section of IAMS.

She has also served on numerous federal and state government groups concerned with ecology and the environment. In addition, she has taken an active role in activities at the University of Maryland, finding time to serve on the faculty council, the committee on the status of women, the committee on promotions and tenure, and many other groups.

Wearing yet another hat, we see Dr. Colwell as a wife and mother. Her roles here are best seen by reviewing her career.

Dr. Colwell grew up in Beverly, Massachusetts where she lived near the ocean. She attended school in a four-room schoolhouse for the first six grades. She remembers her school principal as being very influential. In the sixth grade she was called into her office. The principal said, "You have scored the highest in the IQ test of any student we have ever had. You have a great responsibility and an obligation to use this gift of intelligence well." Dr. Colwell accepted this obligation.

She was the seventh of eight children, and a source of great satisfaction to her parents. Her mother died when she was 15, and with the older children away, she came under her father's

encouraging influence. A traditionally-minded aunt thought she should attend secretarial school or go straight to work, but she wanted to attend college and her father agreed.

She applied and was accepted at Radcliffe, but since this would have meant commuting rather than going away to school, she decided to attend Purdue University in Indiana. Purdue offered her a four-year special merit scholarship.

At that time, Dr. Colwell recalled, it was the usual practice for a young woman to join a sorority. This she did, and later noticed that her roommates, "spoke very highly about a bacteriology course taught by a woman professor, Dr. Dorothy Powelson. Taking a course from her made me change my major from chemistry to bacteriology." This professor was a "pleasant, rather pretty, kindly and gentle woman who was very oppressed in a machismo-dominated department. She was a fine teacher but severely oppressed by her colleagues." Nevertheless, "she affected many people's lives very positively. I personally know several women who were strongly influenced by her. Three are physicians and at least half a dozen are Ph.D. microbiologists, all actively pursuing their professions," Dr. Colwell said.

"Now, society has changed. Women do not have to make all the sacrifices that many of these women science professors made in the past. Many of them never married or had children. They struggled hard just to have their work recognized."

Dr. Colwell married during her senior year at Purdue. Her husband was a graduate student in physical chemistry. Since he was working on his degree at Purdue, she stayed on there. In one year she earned her Master's degree in genetics. She switched from bacteriology to genetics because she was told

that the bacteriology department, "would not waste money on a woman researcher." She talked to her undergraduate advisor, a professor of genetics, who offered her an opportunity to be a research assistant in his genetics laboratory.

After this, both Dr. Colwell and her husband attended the University of Washington. Dr. Colwell had originally wanted to attend medical school, but there were strict quotas at the University of Washington for out-of-state students. So, she pursued her Ph.D. in microbiology.

The one woman in the University of Washington microbiology department at that time was a truly outstanding scientist, but a very reserved person who did not seem to have time to be concerned about human relationships. Dr. Colwell did not seek her counsel, but instead found a male mentor, a professor in the marine sciences, with whom she formed a good friendship and a very strong scientific camaraderie. He was interested in the intellectual development of all of his students. "He and his students often had lunch together and talked about science fiction, literature, Shakespearean drama, and science.

"Together, John Liston and I were sort of pioneers in our field. We were the first in the United States to use computers to identify microorganisms. In the beginning, people did not receive this idea well. We felt a little like lepers. Now, however, computer applications in microbiology and marine sciences are very important."

During 1959–1960 Dr. Colwell was a predoctoral associate at the University of Washington. Then, from 1961 to 1964 she held the rank of research assistant professor. At this stage her husband was awarded a postdoctoral fellowship at the National Research Council of Canada. Because of regulations

that prohibited a husband and wife from working for the same employer, she could not be paid for the work she did. So she sought and received a United States National Science Foundation Grant which was awarded through the University of Washington where she was a member of the faculty. She was granted a leave to do the research work in Canada as an independent investigator. For two years she received funding to conduct her own research, as well as to pay the expenses of a technician.

In 1963 a very good friend and colleague introduced her at a national meeting to a man who hired her on the spot for the position of visiting assistant professor at Georgetown University, in Washington, D.C. She was anxious to move to Washington, since her husband had already found a position there. The man who hired her was, "very kind and supportive, but there was rampant sexism in the rest of the department." However, she later progressed at this university from assistant professor of biology to associate professor, and even earned her tenure.

Yet, when she was offered an opportunity to go to the University of Maryland as a full professor of microbiology, she accepted it. She reports being very happy there. She credits her success to the fact that, "people along the way were very helpful and I have always worked very hard."

Despite a high rate of divorce among her college peers, she said, "after twenty-three years of marriage, I am as much in love with my husband now as when we married." Even in her marriage, Dr. Colwell seemed to know what she wanted and worked at making it a reality.

While working in Canada in 1963 she gave birth to her first daughter. She found a "wonderful woman, Kit Godson, who needed a job. Kit stayed with us for seven years." Ms. Godson helped the Colwells raise their two children, the second of whom was born in 1965. Dr. Colwell also has special praise for her husband. "He always did what the so-called experts in their books now suggest fathers should do—share in child-rearing and household duties."

Dr. Colwell has been actively involved in the education of her daughters. "My daughters have high IQ's. I was very disturbed when one of my daughter's teachers reported that since she was good-looking, it was not necessary that she be good in everything, especially not mathematics.

"This specific incident is typical of the socialization of high school girls away from math. To direct young women away from becoming good in math or from working hard at it, is to deflect young women entirely from science careers. The directing of women away from mathematics is the primary cause of young women not entering science careers," Dr. Colwell emphasized.

Dr. Colwell and her husband both work with their daughter so that she understands mathematics and now does well in it. Her youngest daughter was not doing well in math either. The junior high school teacher recommended that she be placed in a remedial math class. Instead, Dr. Colwell hired a tutor who worked with her and found the problem in school was that she was so bored with the simplistic math being taught that she simply wouldn't do it. When the tutor introduced her to calculus and set theory, she blossomed and now does quite well.

Dr. Colwell cautioned young women that much of this effort to deflect them out of math is subliminal. Women are made to feel inferior in math and not very competitive. "Despite what teachers, counselors, or even parents say, young women can and do succeed in mathematics," she said.

In addition to her career and a full family life, Dr. Colwell also enjoys her leisure activities, of which competitive sailing is one. She and her husband are members of the Severn Sailing Association and have won several championships. She also enjoys gardening and oil painting, but has had almost no time for these activities. "They will be among the pleasures of the retirement years," she hopes.

To successfully perform her numerous roles is a prodigious feat and Dr. Colwell credits her efficiency to "the best staff in the world. The women who work in my office are extremely helpful to me. They are supportive and extraordinarily kind and thoughtful. They show me how to do things in running the office and they take pride in doing things with and for me. They are really very professional in their secretarial jobs. These people are more than employees. They are friends, and we have a good rapport. I have had the good luck to attract and interact with excellent people. I like dynamic and creative people who care about what they are doing. They do more than rush out a letter simply because it is a job," Dr. Colwell said.

Dr. Colwell would agree that part of her success in science comes from her fundamental liking for people. Such an attribute is definitely not incompatible with a successful career in science.

DR. JENNIE TOU

Virologist

Dr. Jennie Tou's story illustrates one of the sad facts of scientific careers. If you take a number of years out of your career for childbearing or for other reasons, you will not be able to reenter the job market where you left off.

Science changes rapidly. Unless you continue your active participation in it through research, discussions with colleagues, and reading the latest journal articles, you will not be able to keep up.

Dr. Tou earned her Bachelor's degree in chemical engineering in 1957 at Cheng-Kung University in Taiwan. She then came to the University of Nebraska where she earned her Master's degree in organic chemistry in 1961. Her advising professor suggested she continue her studies at Ohio State University which she did, receiving her Ph.D. in 1965.

After graduation, she worked for five years as a research scientist in the chemicals group for Union Camp Corporation, Princeton, New Jersey. She participated in research involving finding new and more efficient uses for chemical products derived from trees.

When she began this job in 1965 she earned $11,700 and in six years her salary increased to $16,500 per year.

At the age of 33, Dr. Tou married. For the next six years she stayed home and raised two children. As she reflected on it, "it would have been better not to quit." While she does

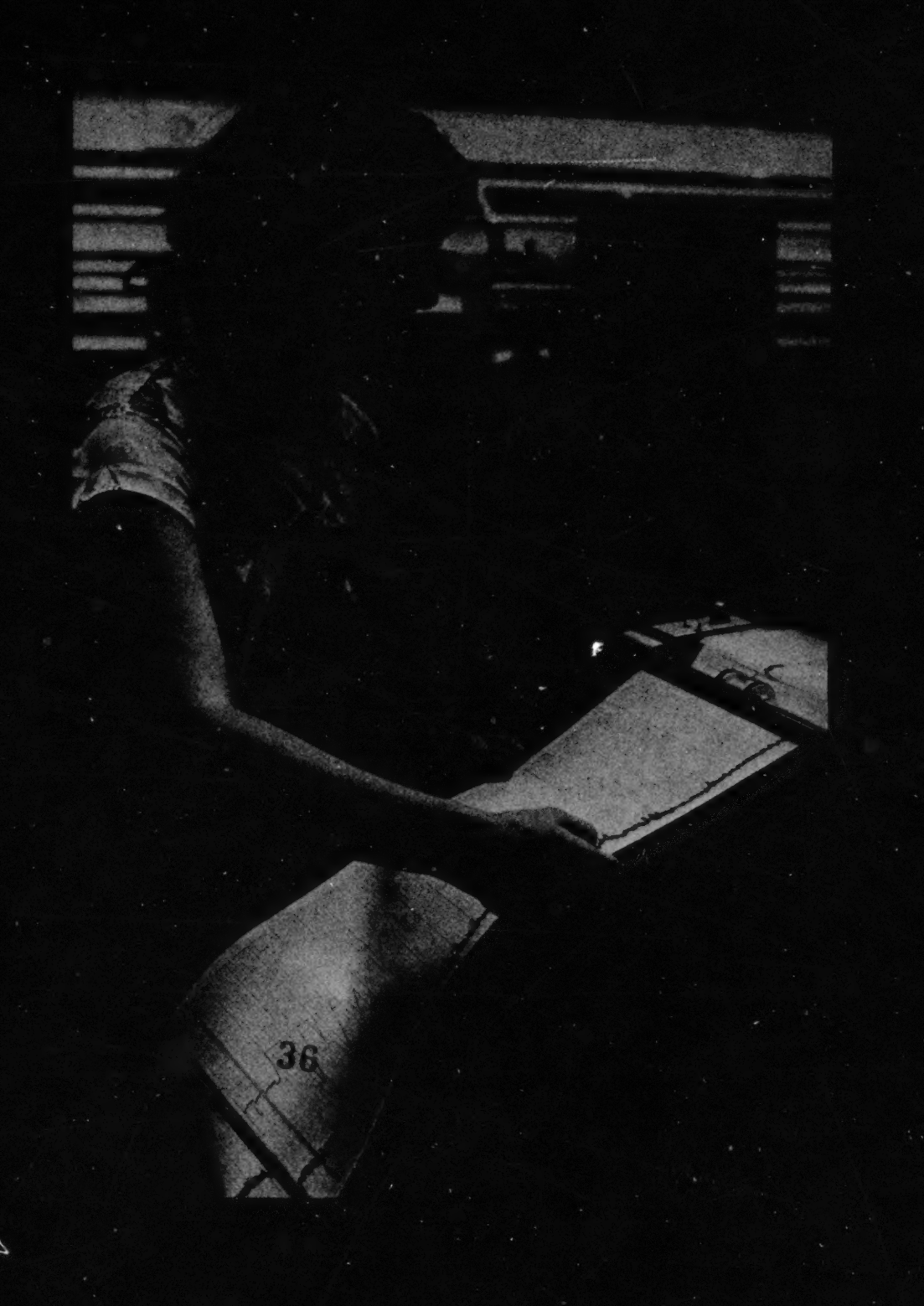
enjoy cooking, sewing, and even cleaning house, she still hopes to return to organic chemistry. Toward this end she is taking a course in organic chemistry at the National Institutes of Health, but much has changed since she was working as an organic chemist.

Currently she is working in a viral science laboratory as a biologist, changing into another scientific area quite different from organic chemistry. She is still hoping to go back into organic chemistry, but has little time to look for an organic chemistry job in the Washington, D.C. area.

As a biologist in a viral biochemistry laboratory, she works on viral protein and polymerazes purification. She also works with RNA and DNA and conducts various research studies.

"Laboratory work requires patience, a clear mind, and organization. You have to arrange what to do first, second, and so forth. You must understand the purpose of the problem. Then you seldom make a mistake. Often laboratory technicians mess up because they do not understand the purpose of the problem," she said.

When her family gets a little older, she hopes to have enough knowledge of current practices and procedures in organic chemistry to reenter the field.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CHAPTER 2

CHEMISTRY

Chemistry is the science that deals with the composition, structure, and properties of substances and the changes they undergo. It is the study of the materials of which the entire universe is composed.

Some chemists conduct research to learn why matter is composed the way it is, ways to make forms of matter that do not exist in nature, ways to separate the forms of matter that do occur in nature, and ways to measure and calculate the energy changes that occur when matter undergoes a change. Some research adds to the accumulated knowledge about our material surroundings; other research produces new forms of matter that are useful to society.

Other chemists apply the results of experiments to everyday situations. This work might involve analyzing problems, gathering data, or monitoring various phenomena. Examples are soil analysis, analysis of material gathered as evidence at the scene of a crime, and determination of the daily pollution index for a metropolitan area.

Chemists have an education that allows them to pursue careers in many areas outside the mainstream of chemistry. Museums, banks, schools, insurance companies, publishers, health and police departments, and all kinds of manufacturers employ people with degrees in chemistry. Even in the large chemical companies, chemists often do work that is far removed from the laboratory—in sales, advertising, information science, patent law, and finance.

Nearly two-thirds of all chemistry professionals work in industry. Educational institutions employ about one-fourth; local, state, and federal governments employ about one-tenth. In addition, chemists work in such diverse fields as technical writing, art preservation, and sales and marketing.

Chemists can be classified according to the five traditional branches of chemistry:

Physical chemists study the physical characteristics of matter and investigate the reactions of atoms and molecules; they seek quantitative explanations stated in precise mathematical terms.

Analytical chemists determine the composition of substances, measure trace contaminants, and separate complicated mixtures in components.

Organic chemists study the properties of both natural and synthetic carbon compounds.

Inorganic chemists are concerned with the broad range of compounds that are formed from the 105 known elements.

Biochemists study the chemistry of living systems—the reactions and processes that occur in the cells of plants and animals.

It is often difficult to classify chemical work into only one of the five traditional branches; sometimes a hybrid of the two is more accurate. Therefore, there are physical-organic chemists, bio-inorganic chemists, and organic-analytical chemists.

Another classification scheme uses the name of the industry, product, or industrial process with which the professional is involved, creating such occupational titles as petroleum chemist, cosmetic chemist, polymer chemist, and food chemist.

A third scheme classifies chemists according to the nature of their activities; for example, the theoretical chemist applies the fundamental laws of nature to chemical reactions while the synthetic chemist develops and researches manmade materials.

In 1974 the Bureau of Labor Statistics estimated that there were 37,700 chemists. By 1985 it predicts there will be 47,100 chemists to fill 43,000 available jobs. This means there will be 3,800 surplus chemists, or 8.1 percent of all chemists will be in excess of demand. On a yearly basis, the Bureau of Labor Statistics has found that an average of 10,064 students earn a Bachelor's degree in chemistry, and 3,583 earn a Master's degree. They compete for 10,000 annual openings.

The College Placement Council found that starting salaries for chemists with Bachelor's degrees for 1977–78 were $15,000 for men and $14,500 for women. The American Chemical Society said the 1978 median starting salary for men with a Bachelor's degree was $12,599 and for women, $12,676. Over 71 percent of both groups were employed by industry.

Women with Master's degrees received a median starting salary of $13,057, 45 percent being employed by industry; but men with a Master's degree earned $15,097 and 77 percent were employed by industry. Among Ph.D.'s, women earned a median starting salary of $17,892 with 58 percent employed by industry while men with a Ph.D. earned $19,605 with 74 percent employed by industry.

The National Research Council found that in 1970–71, women earned 8 percent of the Ph.D.'s in chemistry. In 1976–77 they earned 11.5 percent. However, the National

Science Foundation found that in chemistry, women who had earned their Ph.D.'s in 1977 had an unemployment rate of 5 percent, compared to 0.9 percent for men who had earned their degree in 1977.

In nonprofit corporations the median salary for both sexes was $10,800; $10,000 was the median in the federal government; and $9,100 prevailed in colleges and universities; according to the October 1978 issue of *Chemical & Engineering News*.

The American Chemical Society asked students who graduated in 1978 to describe their positions and offer job-hunting suggestions to others; their advice: "Don't wait until you graduate to start looking for a job." Others commented that, as chemists, they did not find a great number of jobs open to them. Further education in business or engineering would have increased their chances of getting a job.

One newly employed chemist suggested, "Look for the smaller labs and chemical companies—you get a wider variety of work, more challenges, and you can progress more rapidly. Small companies are more apt to hire the average, hardworking student. Large companies seem to hire only the upper 2 percent of the graduating class."

The following six profiles are of 1978 college graduates who majored in chemistry at various public and private colleges across the country:

Helen Weber works as a laboratory coordinator for Union College. She prepares the laboratory exercises for approximately 500 students who use the college lab facilities each week. Other duties include supervision of lab maintenance, supervision of two student aides, and ordering lab supplies.

Her salary in 1978 was $9,000 per year; benefits included flexible hours and tuition reimbursement.

Helga Dressler of Wheeling, Illinois, is employed by Industrial Bio-Test Laboratories as an analytical chemist. Her job responsibilities include analysis of water, soil, plants, and biological tissues for the presence of pesticide residues, food additives, and contaminants. Each analysis requires sample preparation, extraction, and separation, and utilizes such various instrumental methods as gas chromatography and high performance liquid chromatography in conjunction with a variety of detectors. Her salary in 1978 was $11,200 annually.

Ginny Sherman is an analytical chemist in Phoenixville, Pennsylvania, employed by Atlantic Richfield Company. She works in the Analytical Service Department of the Quality Administrative Division. Her work involves the testing of gasoline, furnace oil, lubrication oils, and intermediates by X-ray flourescence, atomic absorbance, infrared spectrophotometry, titrations, microcoulometry, and gas chromatography. Her salary in 1978 was $15,500 per year.

Catherine Hintze of Midland, Michigan, is an instrumental engineer for Dow Chemical Corporation. She provides specialized process instruments to various Dow production areas for quality control, process control, and pollution monitoring. If she cannot obtain a commercially available instrument that will meet the needs of the plant, she must design the appropriate equipment herself. After the instrument is checked out in the lab and installed in the plant, she trains people to maintain it. Her salary in 1978 was $15,600 per year.

Jane L. Beers of Allentown, Pennsylvania, is in chemical sales. Her employer is Air Products and Chemicals, Inc. She moved into her present position after working a year in the company's research and development labs. Her responsibilities include coordinating shipments throughout the United States and Canada, and to several foreign countries. She also oversees the production of quality control reports, and, like all sales people, maintains rapport with customers. Her salary in 1978 was $12,000.

Rachelle Rydzik of Easton, Connecticut, is employed by King Industries as a research chemist. She is currently working on the use of liquid ion exchange as a method for purifying metals. She has applied for a patent as co-inventor of the solvent used in these active ion exchanges. In 1978 she earned $13,500 per year. She finds that working for a small company offers more decision making and responsibility, less red tape, and the opportunity to carry a project from start to finish.

DR. SANDRA GREER

Physical Chemist

People usually picture chemists working in laboratories, juggling test tubes. Not Dr. Sandra C. Greer, who, as a physical chemist, says: "I do not work with test tubes and lots of glass. I have an electronics laboratory. My area is a blend between physics and chemistry.

"My special field of interest is thermodynamics—how energy and matter change form. I am especially interested in

using the tools of thermodynamics to see what goes on in liquids, gases, and mixtures of liquids when they go through different phases or transitions, such as when a liquid becomes a gas or when immiscible liquids mix. This involves statistical mechanics, which is based on the nature of molecules," she explained.

"One of the questions I am interested in is why water freezes at zero degrees centigrade and forms ice. One of my particular interests is supercooled water. Supercooled water occurs when water goes below zero but does not freeze." Dr. Greer wants to see what the molecules do at this stage. To study this phenomenon she received grant money from the Office of Naval Research. Her research in this area will aid in understanding severe weather conditions, because water in the atmosphere sometimes goes through a supercooled stage and forms hail.

Her major area of interest is critical phenomena. This is a phase change in which two forms of matter that are very different gradually grow more alike because of temperature and pressure variations. All liquids have critical points. Liquid mixtures that do not normally mix also have critical points, as do magnets. Dr. Greer enjoys looking at and explaining how substances behave as they near their critical points.

Dr. Greer grew up in a small town in South Carolina, where her interest in chemistry began early. She was always fascinated with how things were put together and what they were made of. As a youngster, she received a chemistry set and a microscope as a present from her parents. Her interest in chemistry continued through high school and intensified at Furman University in Greenville, South Carolina, where she

received her Bachelor's degree in chemistry, magna cum laude, with a minor in mathematics.

Furman University is a church-affiliated liberal arts school with an excellent chemistry department. Dr. Greer recalls that, ". . . since it was a small school, I made good friends and felt good. However, I also got a well-rounded background, which I feel is important."

After graduation, her advisor suggested that she attend the University of Chicago for graduate work. This suggestion, coupled with a long distance call from the University of Chicago recruiter, made her decision easy. "Getting in was no problem. Once there, some people were ahead of me; they knew more, but I could keep up.

"After I passed my exams and went to look for a thesis advisor, I intuitively knew that there were only a couple of professors who would bother with women. There were no women on the chemistry faculty then or now at either Furman or the University of Chicago.

"During college I married another graduate student in chemistry. After graduating, we both landed jobs at the National Bureau of Standards, in Washington, D.C."

Dr. Greer worked as a research chemist at the National Bureau of Standards. She served in the Heat Division of the Institute for Basic Standards from 1969 to 1978. Her work at the National Bureau of Standards was the first time she had seen other women actually doing scientific work, outside of graduate students at college. "It was important for me to see women functioning as both professional scientists and people. I learned it was not impossible to do this. The structure there was quite supportive. When I had my twins, I took off a couple of months and then I worked part-time without any hassles for a number of years.

"I did not personally feel any job discrimination. Though on the whole, when I was there, women with Ph.D.'s and the same experience as men were one whole government grade below them. Yet, in the last few years, this agency and others are quite anxious to get more women into management," she noted.

Dr. Greer is currently an associate professor in the chemistry department at the University of Maryland. She prefers being in the university environment to working for the government or other employers because the university provides greater opportunity to keep up-to-date with the field and to do scientific research that does not have to be goal oriented.

"In my heart I believe, as do most scientists, that we are academics. At any agency, you seek grant money and usually turn it over to your manager and then you must go and do

more work and are not in control of the grant money. This is frustrating.

"At the university, with a tenured job, you get to keep your own grant money and buy your own equipment and do your own hiring of graduate students and postdoctoral people. The freedom is astonishing."

She has just started teaching a graduate-level statistical mechanics course in the chemistry department, and is required to teach one course per semester. She admitted spending at least 65 percent of her time doing course work. "I like teaching. I think it contributes to my research. It keeps me up-to-date and fresh," she explained. For Dr. Greer and many other scientists, work is often indistinguishable from enjoyment, similar to the situation of professional athletes. The excitement and rewards of the profession are exhilarating, she said.

In her spare time, Dr. Greer enjoys reading, going to the theater, gardening, and gourmet cooking. She also enjoys

writing and has had over eighteen articles published in major scientific journals. She has also given numerous talks in universities around the world, and has addressed many professional associations as well. Dr. Greer belongs to several scientific associations herself, including the American Chemical Society, the American Physical Society, the Association of Women in Science, and the American Association for the Advancement of Science. Professional associations do not help with salaries, but they do sponsor valuable publications. They also run employment services both at their conventions and in their publications. In fact, Dr. Greer got her current position through an advertisement in an American Chemical Society journal. Many of the associations also have undergraduate chapters to which students can belong. The chapters often list undergraduate and summer research jobs and may help students select graduate schools.

Although Dr. Greer does not feel she has been overtly discriminated against because of her sex, a disadvantage she did have at the outset of her career was people being too helpful. "I had to fight to get people to let me handle the laboratory equipment. This was a real disadvantage, for in handling your own equipment you learn a great deal.

"Working with all male colleagues does not intimidate me. They do not cut me out. At conventions and meetings social life means a lot. This is when contacts are made and collaborations established. Hearing talks and lectures is just a small part of going to conferences," she said.

Dr. Greer feels it is important to her career and her happiness to have a husband who will carry his share of the load. "We share child care responsibility. When our twin boys were

babies, we had babysitters and then sent them to nursery school. Now I leave for work at 7:00 A.M., so I am generally home around the time they come home from school. My husband leaves for work later, so he is home to see the children off in the morning."

Her advice to young people considering careers in science is that, "unless you love it, there is no reason to do it. In science there are few famous people. You are only known in a limited sense in a small community. Your parents will not read about you in the newspaper. You cannot explain to your mother-in-law what you do or why you do it." She further advised young women: "Do not have children until you can hire someone to babysit and clean. If you have children too soon, it is extremely difficult to establish a career."

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CHAPTER 3

GEOLOGY

"Women in geology are in a much better position to make significant advances than in many professions," claims Dr. Theresa F. Schwarzer, of Exxon Production Research Company. "The current and projected demand for geologists is unprecedented in light of energy and environmental needs. As a result, there is a very active job market. Not only are new job openings being created at a phenomenal rate, but there is an unusually high turnover due to job transitions at all levels of management, creating a vacuum to be filled from below. Coupled with Equal Employment Opportunity (EEO) pressures to hire and promote women, we should see a rapid progression of women up the managerial ladder.

"The number of men entering geology and going on to graduate school, as in other sciences, is decreasing while the number of women is increasing—at a time of high demand. Many science and engineering schools are now courting women students as the numbers of men are declining. This bit of serendipity certainly cannot hurt chances for the hiring and advancement of women.

"Industry is now the pacesetter in affirmative action. Although historically and currently women geologists have also tended to concentrate in academia, where career opportunities are now more limited than ever, the petroleum industry consistently has employed about 70 percent of all male geologists. Petroleum industry attitudes toward women are now very positive. We should take advantage of a profession

where the majority of us can be accommodated in an industrial employment sector which is vital and alert to hiring and promoting women," Dr. Schwarzer explained.

Such optimism is affirmed by the Women Geoscientists Committee of the American Geological Institute, which has also reported that opportunities for women in geoscience are very good:

"The projected employment picture for geoscientists in non-academic jobs is currently very good, and demand for qualified women geoscientists is even better. Diminishing energy, mineral, and water resources and increasing environmental concerns have placed a premium on the unique qualifications of geoscientists.

"Presently, the best employment opportunities exist for geophysicists, geological engineers, economic geologists, petroleum geologists, ground water hydrologists, and environmental geologists. The employment outlook, however, is always subject to changing economic, political, and environmental concerns. Efforts of all employers to fulfill affirmative action plans for minorities and women have placed a special premium on professional women scientists and engineers, who currently are in short supply. Although the academic employment sector is at present virtually saturated, substantial opportunities exist in industry and the federal government.

"There are approximately 35,000 geoscientists in the United States, but only about 1,225 or 3.5 percent are women. Although private industry employs half of all earth scientists, only 18 percent of the women work in private industry. The majority of women (52 percent as compared to 21 percent of all geoscientists) hold academic positions, where new employment opportunities are generally limited. Consequently,

women should consider seeking jobs in the industrial or government sectors, where general job opportunities are improved and where women are in high demand.

"Women are currently entering the geosciences in ever-increasing numbers. At all collegiate levels some 4,900 women represent 17 percent of all students majoring in the geosciences. Although an enlightened era of employment equity has been entered, there are still prejudices to be overcome and attempts must be made to move women into top positions within the profession. Women aspiring to a professional career should also be aware of mobility problems which might arise from balancing family and professional careers, especially if both spouses are in similar professions.

"Although the field aspects of geoscience are often portrayed as rugged, physically strenuous work conducted under primitive living and working conditions, women should not be deterred. In most cases, these stories are exaggerated. Many women have already demonstrated their ability to perform in the field and underground in the mines. And while field work should be considered a basic part of a working geoscientist's duties, many geologists work almost exclusively in the office and laboratory.

"Some career opportunities require specialized geologic and associated scientific knowledge, while others require general background and skills. Students should find out what education is required for their desired career, and tailor their education so that the goals set are realistic. In general, employment recruiters are seeking the student who has a broad, solid base in math, science, and computers, who possesses speaking and writing skills, and who employs a flexible, pragmatic approach to geologic problem solving. A student who can obtain sum-

mer employment with a company or geological survey has an excellent opportunity to obtain insight into their working needs and to establish contacts toward future permanent employment. Today, nearly all employers require geoscientists to have a Master's degree, while a Ph.D. is required for most research and/or university teaching.

"There are no reasons why a woman should not find geology an interesting and rewarding career. However, she must be able to compete effectively. A woman considering geology as a career should optimize her employability through a strong science or engineering education. In the final analysis, she will be hired not because she is a woman geologist but because she is a *good* geologist," the Women Geoscientists Committee stated.

The College Placement Council reported that in 1979, beginning salaries for men with Bachelor's degrees in geosciences were $15,300 and $15,100 for women. In 1978–79 offers to geoscientists with a Master's degree were $19,032. No breakdown based on sex was given.

DR. HELEN McCAMMON

Ecologist

Dr. McCammon was trained in geology and still identifies herself as a geologist, though her current position demands broad interdisciplinary knowledge.

Dr. McCammon was recently appointed director of the Ecological Research Division of the U.S. Department of Energy, and with this appointment moved from the ranks of researcher to that of manager. Her responsibilities include overseeing ecological research and appropriating, as needed, the Division's $38 million budget.

Before this, Dr. McCammon was manager of the marine science program of the Office of Health and Environmental

Research in the Department of Energy. She administered $14 million in grants for research in marine sciences. At that point, she said, "My role was to plan and implement an effective program in environmentally-related marine research."

Some of the research these grants supported was for "basic research on the hazards of radioactivity, tracing fallout on water and land to see where radionuclides were going. Through this, we can actually trace the cycling of many chemicals and determine the nature and the rapidity of ocean circulation." This program also funded research in biological oceanography to study effects of energy systems on the various parts of the food chain. To best understand how Dr. McCammon came to her present high government position, we will trace her career from college to the present.

Dr. McCammon received her Bachelor's degree with honors from the University of Manitoba. The next year she received her Master's degree from the University of Michigan. Three years later she earned her Ph.D. from Indiana University. She earned all her degrees in geology.

"After completing my dissertation in paleontology, I felt I needed to learn how marine organisms lived today before trying to interpret how they lived in the past. So I started to research living invertebrates, especially brachiopods. Brachiopods look like clams on the outside, but are quite different inside the shell. They were common some 300 million years ago and then declined, but there are still quite a few in areas like New Zealand, the Antarctic, and in cold water regions. By collecting them myself, I was able to visit many remote areas in both the Northern and Southern Hemispheres.

"As a woman I have had a few rough times," Dr. McCammon admitted. "At one university, the department chairman, who definitely did not like working women, gave me $200 to start my research on living animals. With the help of an adjunct professor who had recently retired from industry, we were able to set up a fully operational laboratory for studying sea animals, despite the lack of proper funding.

"As my laboratory situation became stable, I was awarded grants by the National Science Foundation to study the ecology and behavior of brachiopods. I participated in cruises to the Antarctic and Tasman Seas, as well as in land-based studies along the coast of Chile, New Zealand, Quebec, and British Columbia. Some of the oceanographic cruises lasted between thirty and fifty days."

Dr. McCammon's career did not run smoothly uphill, however. "As soon as I began succeeding with what I was doing, much of the support from the faculty stopped. I was seen as a threat to many male colleagues. When I brought this up on one or two occasions, I was told I had become paranoid," she explained.

"In my experiments I began to make discoveries contrary to the food pyramid, which states the lesser animals are eaten by more advanced animals in the food chain. My experiments indicated this was not the case with the brachiopods. When one of my papers on this subject was published, I was told it would be in line to receive the best paper award in my area since it was so innovative. As it turned out though, I never received this award because, as I later learned, the men on the judging committee did not think such an award would be as helpful to a woman's career as to a man's.

"When I talked and wrote about my ideas, I was challenged and grossly misquoted in the literature by a small group, probably not so much because I was a woman as because I was outside their accepted clique. Yet, my research has spawned many other papers, including a number, interestingly enough, by the people who misquoted and misinterpreted my work in the beginning.

"I also had some problems getting my publications into print. Some of the most opinionated men used to sit on review panels. This was obvious from the reviewers' comments that were sent back to me. I had faith that I was on the right track, however, because I continued to get funds for my research from the National Science Foundation; or at least I got them up to a point, for as I was reaching a pivotal phase in my research, the National Science Foundation did not renew my grant," she explained.

"At this time I was teaching at the University of Illinois, Chicago Circle, as a visiting associate professor. Although the university was looking for a faculty addition in my field, I was not considered; instead, the department discontinued my salary and wanted me to continue working as a nonsalaried faculty member. My Ph.D. was worth just as much as the others on the faculty and I refused to tolerate this state of affairs. So I moved to the Field Museum in Chicago to finish up my grants and obligations to the National Science Foundation." It was at this point that, rather than trying to continue my research, I decided I would try to get a job in a funding agency so I could promote creative research regardless of where the researchers had gone to school, or their sex.

"Shortly after this I worked for the Environmental Protection Agency in Boston. Here I tried to push some good

projects. When a fresh proposal came in, I wanted to fund it. But in the position I had, I could not do this easily. In my present job, I'm glad to say, I have the authority to do this.

"One pleasant aspect of my work has been the help of many people in other departments with whom I have associated. During my time at the university, I worked with people and used equipment in biology departments, medical schools, and private laboratories. What aided me was knowing that there were people out there willing to help. It is a joy to think about them and indeed they have provided me with the background and experience necessary for the advancement of my career."

Dr. McCammon cites the supportiveness of her husband as a valuable asset during times of professional stress. In addition, he has shared the responsibility of raising their two children, both of whom they view with great pride. "My 21-

year-old daughter has gone off to get her Ph.D. in solid state physics in Australia. She is a fighter and achiever; she won't take discrimination sitting down. My son is a college freshman and extremely creative; he loves to design different types of rockets and machines. He does not like stressful competition."

While she worked and had children at home, she hired a full-time housekeeper. "Even when we only made $2,000 a year as students, we had someone come in to help with the children. I believe you have to pay other women adequately if you employ them at home. I want to give other women the breaks I want for myself. When I got a raise, so did my housekeeper. Thus, she was very interested in my professional career advancement. Relatives, however, thought I was not a worthwhile wife and mother because I did not do things the traditional way. However, my husband supported me and helped out. He also helped assuage my terrible guilt about not staying home with the children.

"When our son was born, he had several health problems so I had to take off one and a half years from my work since we were always going to the doctor or the emergency room. This was an emotional drain."

After this period Dr. McCammon returned to work at the university. When she came home from work, she spent three to four hours each day with the children. "It was a joy to be with them. I believe it is how you spend your time with children rather than simply the amount of time you spend that is important. We now go backpacking and hiking. We operate as a family. Yet, each of us is independent and self-reliant. When we get together, we are very close. Because I was

working, the children learned to be self-reliant and helped out with the chores as they were growing up.

"Often when I went to biologic stations, we went together. The children helped me collect animals and helped out in the laboratory. In fact both my husband and I involved the children in our work. By the time our daughter was 12, she was one of the best laboratory assistants I had."

Dr. McCammon's own career proves that women's careers need not be bound by geography, even when they have a family. For three and a half years she commuted from Boston to Chicago and Washington, D. C., where her husband was working. Also during that time, her husband and children went to New Zealand for one year, where she visited them twice.

"In a two-career family, if one person accepts a job, the other person should spend time to look around and see if he wishes to make a change at the same time or wait until he has found a position to his liking before leaving his old job. Otherwise there is likely to be a period of unemployment and uneasiness for one person," Dr. McCammon commented.

"Many universities will take one spouse and hire the second only as an accomodation. Usually the university will hire the man and agree to take the woman as a research or teaching assistant, even if she is as qualified as the man in her own field. This is what has happened to numerous well-educated women." Based on her own experience, she advised, "Go after the best jobs, not the ones with the least resistance where you will be paid peanuts.

"A lot of women build fences around their opportunities, citing family or other responsibilities. If a woman chooses to be a full-time homemaker, she should do so because she really wants to. . . .

"In the future I want to work with people and be involved in a lot of areas, but I also need to be associated with research. I have no clear-cut goal of what I should be doing. I want a challenge. I do not want to get into a rut," she said.

In each of her positions Dr. McCammon has thought about what she is doing with an eye toward career change, career development, and career enjoyment. Making the move from the university and research to the government and management was a big step. Dr. McCammon received professional job counseling on how to do this.

The lessons she learned were so valuable that she now conducts job-hunting and résumé-writing seminars for women in geology herself.

Specifically in geology, Dr. McCammon has learned about women facing problems of discrimination. During the workshops she conducts for women, she trains them in ways to answer embarrassing questions. Some of these questions have involved the contention of male interviewers that women in the field cannot carry heavy objects such as rock samples, or that women do not have the stamina to go out into the field for mapping. Dr. McCammon hopes that her coaching will enable young women to overcome these prejudices and find well paid, responsible positions.

Despite the drawbacks and the hardships, Dr. McCammon believes a professional scientific career is worthwhile for a woman because, "it helps her see herself as a fully competing individual, and not solely as a woman."

CHAPTER 4

ASTRONOMY

Astronomy is the science of the celestial bodies. Astronomers, simply stated, are scientists who study astronomy. But a more detailed description of the astronomer's concerns is contained in *Space for Women: Perspectives on Careers in Science, A Symposium for Women on Careers in Astronomy, Astrophysics, and Earth And Planetary Sciences,* sponsored by the Center for Astrophysics, jointly administered by Harvard University, Radcliffe College, and the Smithsonian Institution:

"Astronomers attempt to answer the 'why' and 'how' of all the phenomena observed in the skies. Groups studying the sun are discovering enormous holes in the very high-temperature solar atmosphere, holes that we now think may have contributed substantially to the solar wind that envelopes the earth. Such structures may have profound effects on our climate. Other researchers have found that the space between the stars is much hotter than anyone ever expected.

"Certain more exotic species of stars and objects are being studied. There are also objects such as black holes, pulsars, and quasars, which are giving out tremendous amounts of energy in very strange ways. Researchers are challenged in trying to figure out what is going on.

"One of the greatest puzzles of all concerns the closest star, the sun," according to Andrea K. Dupree, astrophysicist at Harvard College Observatory. Dr. Dupree's research concerns the structure of the sun, stars, X-ray sources, and the

interstellar medium. Dr. Dupree is married and currently works part-time; the rest of her time is devoted to her two preschool children.

"Other studies concentrate on stars—how they are formed, what their properties are, how they evolve, what they will look like in a thousand or a million years, how they die, and the galactic consequences of their deaths. These astronomers try to understand how the universe behaves by studying the life histories of individual stars."

Other scientists such as Dr. Vera Rubin, whose story follows, are interested in the evolutionary patterns of galaxies or entire groups of galaxies.

Again according to the Symposium, "A special fascination of astronomy is that it overlaps with many scientific disciplines. Principles of biology, chemistry, geology, and physics are applied to understanding the evolution of our solar system and the formation of life on earth, as well as to speculating about life on other planets in other solar systems in other galaxies."

Our space exploration program now includes women as astronauts. Women also study the samples of moon rock brought back to earth. One such person is Ursula B. Marvin. Dr. Marvin spent years doing geological field mapping and searching for ore minerals in South America and Africa. "I began studying meteorites. It was an ideal time (1961) for a geological-mineralogical background to be applied to the space sciences," she commented. Today, more geologists, including women, are needed to enter this field." (See the earlier chapter on geology.)

There are 3,500 astronomers in this country. Of these, probably 2,000 are involved in astronomical research. Of the

total group about 300 are women. Some work at universities and others work for the federal government at the National Aeronautics and Space Administration (NASA), the National Science Foundation, or the Goddard Space Flight Center.

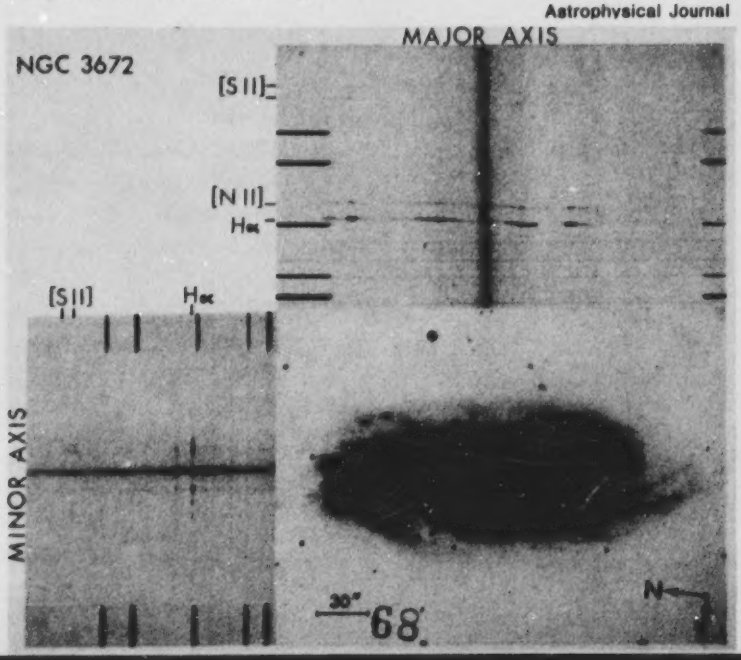
Universities and the government offer the bulk of astronomical positions for both sexes, but only 27 percent of the astronomers teaching at junior colleges, and 12 percent of the astronomers at four-year colleges, are women. In addition, according to the 1973 Report of the American Astronomical Society's working group on the Status of Women in Astronomy, "A higher percentage of men hold prestige and/or permanent (tenured) positions than do women. The bulk of women are research associates, assistant professors, instructors, and lecturers. . . . Over 52 percent of the women hold nonfaculty positions and only 25 percent of the women have tenured appointments, compared to 35 percent of the men who hold nonfaculty positions and 41 percent of the men who have tenured positions.

One of the problems in astronomy, as in many other fields, is the accessibility of equipment and money. Without access to telescopes and computers, for example, astronomers of both sexes have a tough time. However, women astronomers do not, generally speaking, face any more difficulties than their male colleagues in obtaining telescope time or in getting a professional paper published.

Because of limited government and private funds, astronomy is currently a tight field. The Bureau of Labor Statistics reports that each year 152 people are graduated with a Bachelor's degree in astronomy and 159 others are graduated with an advanced degree in this field. Yet, there are only thirty annual openings for astronomers.

Besides not being able to find a job, astronomers also complain about lack of job security and research funds. These problems particularly afflict women, as do the problems of dead-end jobs with no hope of advancement. Many women astronomers also complain about not being taken as seriously as their male counterparts.

Sources of satisfaction to astronomers often vary according to the sex of the astronomer. Only 13 percent of the men (but 22 percent of the women) rated colleagues as important. This may be related to the women's complaint about isolation—perhaps more women work on tasks without others around. The work itself was rated an important area of satisfaction by 22 percent of the women and 16 percent of the men. The freedom to make choices about teaching and research was rated as important by 19 percent of the men and 14 percent of the women.



The salary charts which follow indicate the differences between salaries paid to male and female astronomers. Currently, while salary figures are higher, the range of the differences between salaries paid to males and females is still in effect.

Mean Salaries at Various Institutions[a], 1973*

Institution	Salary[b] (No. Respondent)	
	Male	*Female*
Government	$22470(90)	[$29000(5)][c]
Industry	20260(29)	[17500(1)]
Nat'l. Obs. and Labs	19460(42)	[21250(2)]
Planetariums	[19380(4)]	
Other	17500(20)	[15000(3)]
University	17170(263)	12400(32)
Jr. College	[16560(8)]	[14170(3)]
Four-Year College	15000(22)	[16670(3)]

[a]Ph.D.'s only; all salaries corrected to full-time. No retired, unemployed, or graduate student. Information from AAS questionnaire.

[b]Salaries in brackets are based on too few respondents to be significant.

[c]The Committee on Women in Physics (APS) found that at government installations women's salaries were significantly higher than men's. Upon examination this turned out to be because high administrative positions did not go to women so they remained in scientific jobs for many years with continually increasing salaries. Beyond a certain level men became administrators, so male scientists in government jobs tended to be younger and, therefore, have lower salaries than the women scientists.

*Source: *Report to the Council of the American Astronomical Society* from the Working Group on the Status of Women in Astronomy, 1973.

Mean Salary for American Astronomical Society Members[a,b].*

Degree	*Men*	*No.*	*Women*	*No.*
Ph.D.	$18470	477	$15194	49
M.A.	$18030	33	$17500	8
B.A.	$16620	17	[$20000]	3
All	$18395	531	$15742	60

[a]Information from AAS questionnaire.
[b]Values in brackets are based on too few individuals to be significant.
*Source: *Report to the Council of the American Astronomical Society* from the Working Group on the Status of Women in Astronomy, 1973.

The American Astronomical Society, located at 1717 Massachusetts Ave., Washington, D.C., is an important organization to which most astronomers belong. It recently had its first woman president, Dr. E. Margaret Burbidge, who is an expert in extragallactic astronomy and an excellent astronomical observer. She is employed by the Department of Physics at the University of California, San Diego, in La Jolla.

As other professional societies, the AAS often meets on university campuses, publishes journals, and holds meetings where astronomers get together to discuss their work. It also offers membership to students and maintains a standing women's committee.

Another professional group is the International Astronomical Union. Its members come from all countries and meet every three years. Women in this country do as well in astronomy as elsewhere in the world, according to Dr. Vera Rubin, a member of this elite group.

Dr. Rubin's story follows. Note in it how she, like so many women, has balanced her family and home responsibilities with those of her career.

DR. VERA RUBIN

Astronomer

In March, 1979 Dr. Vera Rubin made national news by identifying a giant spiral galaxy of billions of stars that is the largest, most massive galaxy sighted in the universe. This galaxy, which resembles a giant pinwheel, probably contains ten times more matter than the Milky Way, the galaxy in which our solar system is located. The details about NGC 1961, as this galaxy is called, were discovered by Dr. Rubin and two other astronomers. Dr. Rubin made her optical observation with the large telescope at Kitt Peak National Observatory in Arizona.

This discovery is among the many important findings Dr. Rubin has made. She believes, "Now is an exciting time to be an astronomer because the current development of more sophisticated instrumentation has led to real breakthroughs.

"A tremendous amount of information is coming in rapidly. All kinds of phenomena are now being discovered because of the equipment available. Even if you cannot get the time you request on the giant telescope at Kitt Peak National Observatory or at the other large observatories, smaller telescopes give enough information so you can learn new things," Dr. Rubin explained.

Dr. Rubin is an observational astronomer at the Department of Terrestrial Magnetism of Carnegie Institution in Washington, D.C. She looks at the sky, takes pictures of what she sees, and then measures these pictures under a microscope to reach her conclusions.

Some astronomers use balloons or rockets to carry their equipment high in the atmosphere. Others use radio telescope observations of different radio wavelengths as a way to discover facts about the universe.

One of the co-discoverers of NGC 1961 used a 300-foot diameter radio telescope to study radio emissions from the galaxy. Dr. Rubin has not used space experiments in developing her observations, but she has served on advisory boards to NASA.

Dr. Rubin remembers watching the stars from her bedroom window as a child. This was the way she got interested in astronomy. At about the age of 12 she spent most of her evening hours watching the stars and reading. Someday she hopes to write a book for children, to interest them in the stars.

Her father, an engineer, encouraged her in her astronomical interests. However, he thought that she should study mathematics because, "One could not support oneself doing astronomy. He was wrong," she added.

Throughout her life, Dr. Rubin has been engrossed in astronomy. Most of her work is done during the day at her office in Washington, D.C., although she uses a telescope through the night from 6 P.M. to 7 A.M. for about five nights every few months. She especially tries to get telescope viewing time in Arizona, Chile, and California, where the best telescopes are located.

"In 1965 I was the first woman permitted to observe at Palomar Observatory. Previously, I had received a form letter which said, 'We regret to inform you we are unable to accept applications from women,' Today, however, there have been tremendous changes. Many women now routinely use the telescope.

"All of my work is related to the motions of galaxies. At the telescope, I photograph the spectra (light wavelengths) of galaxies. I develop these during the day, bring them home, and measure them under a microscope. Then I interpret the results. They tell how the stars in the galaxy are moving.

"The stars are all gravitationally bound to the center of a galaxy and rotate around it. From the measurements I can deduce how fast they are moving, and how the mass is distributed in the galaxy," she explained.

"My work is extremely exciting. It is a joyous way to live. I cannot wait to get to work," Dr. Rubin bubbled.

"I have spent three to five years studying the spiral galaxy in Andromeda, the nearest spiral to our own, and an equal

amount of time on large samples of other galaxies, to see if there is expansion of the universe in the same direction."

Is the universe expanding with the same speed in all directions? Before Dr. Rubin posed this question, almost no one had ever worried whether the universe's expansion was the same in all directions. "I observed the velocities of a sampling of galaxies at the same distance, but distributed in all directions. The answers are still unclear but the results of our work (she works with another astronomer) show that expansion does not occur at the same speed in all directions. It seems to vary systematically across the sky.

"It is most likely that our galaxy has a rapid motion, so we are moving toward some galaxies and away from others." This finding has caused heated controversy, she said, adding that, "I have found controversy hard to take. I enjoy doing what I want to do and, hopefully, doing it well. However, a few astronomers have disputed my findings and said our galaxy could not be moving so rapidly. My difficulty in accepting controversy may be related to my being a woman. I had to learn to stand up to the most eminent astronomers. I was willing to admit that I might not be right, but they were not. Ironically, there is still not enough data to answer this question and others that I posed about the velocity of our galaxy.

"Even though the answers may take years in coming, this does not lessen my interest in asking provocative questions," Dr. Rubin explained.

Dr. Rubin considers her strong point and greatest success to be asking questions that have not been asked before and then going out and gathering data to answer them. "Sometimes the

answers are so complicated that definitive answers cannot be given." But these questions and research have interested others in examining questions from a variety of viewpoints.

"Currently, the data I am getting is so clear and unambiguous that there is little controversy surrounding it. I have been studying the rotation of galaxies. Because the telescope I use is so modern, I have been able to observe even the faint outer parts of galaxies and to better understand stellar motions.

"I am able to show what only a few people predicted. In the outer part of galaxies the stars are moving at velocities much higher than expected. Planets far away from the sun rotate slowly. It was thought that in galaxies the stars far out would also rotate slowly.

"However, in our systematic study of many galaxies, our results show that stars far out rotate rapidly. This was a very pleasant finding because it means there is very much mass in galaxies at large distances from the nucleus. It may force us to reconsider what a galaxy is. Any clear result that is not expected is bound to lead to very great advances in our understanding," Dr. Rubin noted.

"Something else we just discovered was really exciting. I picked twenty of a very specific kind of galaxy. They ranged from very little through gigantic. We studied how they rotated. I found they all obeyed the same kind of relation. The little ones followed the same path as the big ones: all obey the same rotation law. This showed that all galaxies, whatever their size, are part of the normal rotation. I would previously have predicted that they had individual rotation patterns. Instead, the twenty galaxies' rotation paths all fit on top of each other. This finding went way beyond what we expected to find," she declared.

Dr. Rubin traced her career: For her Bachelor's degree she attended Vassar. In her senior year she requested a catalog from Princeton University's Graduate School. Because she was a woman, they refused to send it. Instead, she joined her husband at Cornell University, where she obtained her Master's degree. "My husband was working for his Ph.D. in physics when we got married and came to Washington," she said. "I had one child when I got my Master's degree at Cornell. For six months I took care of David, whom we adored. I changed diapers and did all the other domestic duties. I was miserable. I knew that was not the way I wanted to live. I wept when the astrophysical journals came in.

"So, I went back to school at Georgetown University and earned my Ph.D. in three years. At this point, we had two children. The hardest part of being a student and mother was working on my thesis at night when the children were asleep. I vividly remember the total exhaustion of getting into bed at 2 A.M. But I persisted and finally accomplished my objective."

During this time and for some time afterwards, "I stayed on and worked at Georgetown University teaching a few nights a week. At Georgetown I asked for and got a job that would last only until 3 P.M. so I could come home and be with the children.

"Naturally, though, there were times when I wondered whether I really would be an astronomer. For one thing, I had a nonestablishment background—Cornell and Georgetown were not the schools most eminent astronomers had attended. I wondered whether I would get a job with other astronomers.

"In 1965 I joined the staff of the Carnegie Institution of Washington, and until 1970 I got paid for part-time work because I continued to come home at 3 P.M. However, I put in long hours working at home, probably more than full-time. This so-called part-time status worked well and did not hinder my professional career."

She believes that one of the major reasons she was able to be free enough to do her work was the encouragement of her husband and family. "I have a very cooperative husband and four children. The last child is now in college. The children always knew my work was important to me. We are a close family.

"My husband shares the duties of the house. We live in a large, older house in the District of Columbia. We have lived

here since the children were growing up. This location permitted them to walk or take buses wherever they needed to go. I was free to do my work rather than chauffeur them around."

The Rubin home is a comfortable place. The walls are lined with books—scientific as well as some of the latest fiction and nonfiction. Where there are not bookcases, the walls are hung with fascinating pictures, one of an area near an observatory Dr. Rubin liked, and abstract paintings pulsating with color and energy.

Dr. Rubin is pleased with the progress of her children. Two of her sons are geologists, one daughter will soon have her Ph.D. in physics, which is close to astronomy, and the other son is working toward a Ph.D. in mathematics.

Dr. Rubin smiles and talks excitedly when discussing her work. She illustrates her points with pictures. She is willing to give other people credit for their work.

Dr. Rubin has advised other women on careers in astronomy. She believes, "You need an advanced degree if you want to pick your own research programs. With a Bachelor's degree in astronomy you can be a technician or research aide or programmer, but it is not nearly as much fun. The same is also true for physics and chemistry."

Dr. Rubin, like many other research scientists, prefers to pick her own topics for research rather than work for government or industry, where you must work on topics that others choose. "In these instances, if there is a job to be done, then you fit in. It often calls for great originality, but it is not the true freedom to do what you want at any given time," she said.

While women have made progress in getting to use observatories, most astronomy departments do not have any

tenured women on their staffs, Dr. Rubin explained. There are few women who are currently entering astronomy. But even though the job market for astronomers is tight, Dr. Rubin stresses that, "if you want a job as an astronomer, you can get one. When the job market is tight, women have a harder time. However, astronomy is being taught in many more places now and people can probably get jobs teaching at smaller schools.

"If you are absolutely outstanding you will survive. But men who are very capable and very bright but not absolutely tops are able to survive more easily than women in this category.

"Women still face problems at the graduate level and on the faculty. This is especially true if the husband of the woman is also on the faculty. Many schools still, either overtly or covertly, keep to an anti-nepotism rule that prohibits both spouses from teaching in the same department or even at the same school. One survey of women astronomers found that 65 percent of them were married to other astronomers, physicists, or other scientists, so the question of nepotism rules is very important," she said.

"In astronomy as in other science fields there is an old guard that is all male. They are slowly retiring and being relieved of their decision-making authority. This should relieve some of the most blatant types of discrimination against women," Dr. Rubin observed.

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CHAPTER 5

PHYSICS

Physics deals with matter and its subatomic components, including electrons, protons, neutrons, atoms, nuclei, mesons, and electric and magnetic fields. Physicists seek out the laws that govern the behavior of these subatomic entities.

A large percentage of physicists engage in research. Industries such as Bell Labs, Xerox, General Electric, Ford, Westinghouse, and IBM sponsor applied research that can be useful to the improvement or development of their products or services. This might include inventing or developing electronic devices, biomedical equipment, or new materials.

One such person is Diana McSherry, a research biophysicist and executive vice president of Digisonics Corporation. She developed a system which uses ultrasonic waves and computer processing to produce images of the inside of the human body. As a result of her work, doctors can view the inside of a patient's body without making an incision. Dr. McSherry described her device this way: "It puts out a sound wave, like a beam of light. This sound goes into the body and is reflected from the heart. From the reflections one can form an image of the heart, but this image is very rough. If the data are recorded and fed into a computer, the picture can be focused."

Besides industry, government laboratories such as at the National Bureau of Standards, Brookhaven, Oak Ridge, Fermilab, Los Alamos, Lincoln Labs, and Argonne National Laboratory all provide an opportunity for physicists to do both basic and applied research in various areas. Such research

includes high energy physics, nuclear physics, medical physics, energy research, and solid state physics. Physicists in these areas may work on breeder reactors, laser fusion, solar energy, and geothermal energy.

The various fields of physics have been described by the Committee on the Status of Women of the American Physical Society:

"The areas of physics are far-ranging. The invention of the laser has added tremendous excitement to the traditional area of optical physics. Lasers are used for making holographs, a photograph that produces a three-dimensional image. Lasers are also used for microsurgery and as sources for spectroscopy. They show promise in communications and energy research. Recently, integrated optics, an analogue of integrated electronics, has become a promising area of research.

"Solid state physicists and materials scientists study crystals of metals, insulators, and semiconductors. Now there is much interest in amorphous semiconductors, liquid metals, and liquid crystals, as well as in superconductors, ferromagnets, and organic conductors. Many solid state physicists are interested in understanding the behavior of these materials."

One physicist working in this area is Judy Rosenbaum Franz, a professor at Indiana University. She has done many experiments on the ultrasonic velocity and nuclear acoustic resonance of various metals. The findings resulting from such experiments are used in producing devices such as transistors, integrated circuits, and computer memories.

Nuclear physics began with research in radioactivity for which Marie Curie received two Nobel prizes. Another woman, Maria Mayer, shared the Nobel prize in physics in

1963 for her work on the shell model of the structure of the nucleus. Dr. Evans Hayward, whose story appears in this chapter, is yet another scientist working in the exciting field of nuclear physics.

Again quoting the APS Committee, "High energy physicists produce and study strange new particles—baryons, mesons, neutrinos, and J-particles—by accelerating the more familiar protons, neutrons, and electrons to tremendous energies to bombard targets, and then detecting what comes out. In this way they study the most fundamental constituents of matter and the forces between them. High energy experiments take place at large facilities and often involve large teams of physicists working together. This field, which is highly dependent on government funding, has a particularly tight job scene.

"Astrophysicists use radio and X-ray telescopes to study distant galaxies and other sources of electromagnetic waves. A woman graduate student, Jocelyn Bell, recently discovered a flashing radio source called a pulsar, which might be a very small and dense star made up almost entirely of neutrons. Quasars, black holes, and other puzzling astronomical objects promise to excite interest for a long time. Like high energy physicists, many astronomers make use of large research facilities.

"Cryogenics is the study of the production of extremely low temperatures and the behavior of materials at these temperatures. At the other extreme, plasma physicists are attempting to produce thermonuclear power from plasmas of hydrogen or deuterium gas confined in magnetic fields at temperatures of millions of degrees Celsius.

"Biophysicists apply techniques of physics to problems in various biological fields, such as molecular biology and biochemistry. The conduction of nervous impulses, processes occurring across membranes, and the structure of biological molecules such as DNA have been problems under active investigation by biophysicists." Dr. Eugenie Mielczarek, whose story follows, is currently involved in this area.

"The use of radioisotopes in the detection and treatment of cancer is just one example in the growing area of medical physics, of the application of techniques developed in various areas of physics to problems of medicine.

"Atmospheric physicists are concerned with weather patterns. They construct sophisticated computer models of the atmosphere. They also study pollution control and other environmental problems."

Acoustics, chemical physics, atomic physics, oceanography, and geophysics are other important areas of research conducted by physicists.

Though these fields are very exciting and offer many challenges, because of a cutback in funding for basic research, the number of new physicists employed will be severely limited. In a tight job market, women generally have a harder time than men finding jobs. The extent of the problem is evident from the following figures:

In 1974 the Bureau of Labor Statistics estimated that there were 24,700 physicists employed in this country. By 1985 there are expected to be 31,400 physicists, but demand for only 25,900. This means that 17.5 percent or 5,500 physicists will be surplus. A 1977 estimate of the number of physicists was 26,000; in 1979 there were some 900 women physicists.

Seen another way, the Bureau of Labor Statistics also reported that each year an average of 3,625 students earn a Bachelor's degree in physics, and another 2,308 earn an advanced degree. They compete for 3,000 job openings.

The National Research Council said in 1970–71 women in physics and astronomy earned 2.6 percent of the doctorates while in 1976–77 they earned 5.6 percent. However, the National Science Foundation found an unemployment rate of 5.7 percent for women who had earned their Ph.D.s in 1977, compared to 1 percent for similarly educated men in physics and astronomy. There may be some lessening of the sexism problem because, while women physicists still have a higher unemployment rate than their male colleagues, the unemployment figure for women in physics has dropped to 5.7 percent from the 7.8 percent it reached in 1975. On the average, salaries for women physicists are 87 percent of men's salaries.

In 1977, four-year colleges and universities paid a median annual salary of $24,600 to male physicists and $21,500 to female physicists. The federal government paid a median annual salary of $29,700 to male physicists and $28,500 to female physicists. Business and industry paid a median annual salary of $29,900 to male physicists and $25,000 to female physicists. However, women physicists earn a greater percentage of their male counterparts salaries than do women in other areas of science, according to Dr. Lynn Wilson of Bell Laboratories.

Despite the tight job market, there is always room for physicists who are extremely creative. Women who enjoy physics should definitely consider becoming physicists.

In 1975 the president of the American Physical Society, one

of the more prestigious scientific groups, was a woman—Dr. Chien Shiung Wu, a professor of physics at Columbia University. Dr. Wu is also noteworthy because of her own research. In 1975 she performed an experiment that disproved what had seemed to be a basic law of physics, the law of conservation of parity.

Dr. Wu and other women physicists have conducted research in many areas and are continually making new discoveries. The following profiles of two women physicists prove that there are a variety of areas open to women in physics and, while the going is not easy, the rewards are great.

DR. EUGENIE MIELCZAREK

Physicist and Teacher

Dr. Eugenie Mielczarek is one of approximately 900 women physicists in this country. She is very dedicated to her work and to the advancement of other women in physics.

She grew up in New York City. Her father was a tax accountant and her mother never attended high school, but Dr. Mielczarek explained, "She is one of the most literate and brilliant persons I know."

Dr. Mielczarek's father worked as a comptroller for the American Institute of Physics. This allowed him access to

such great physicists as Enrico Fermi and Robert Oppenheimer. Though she did not get to meet them, she felt close to them through her father's associations.

She attended a Catholic elementary school where no physical science was taught. She feels that this may be the reason she was not turned off by the sciences. "Too often, elementary teachers are insecure in their teaching of physical science. They lack confidence and information so the image they project is that of a woman who feeels uncomfortable with what she is doing. This is often seen by young women as a cue that they should not be too interested in this field; it is out of their realm. Young boys, by contrast, tend to see what the teacher is doing as magical and intriguing."

However, she did take physics in high school. There, at an all-girls Catholic high school, she had an excellent teacher who encouraged her to go into physics. During this time she took a physics textbook out of the library and thought it was, "the most challenging thing I had ever read. It was something worth spending time at. Other subjects were easy; they were no challenge. I liked the intellectual challenge of physics. I found physics in the framework of mathematics very satisfying.

"After high school I announced that I planned to attend Queens College, a public, free university in New York City. My father offered to send me to a secretarial school. My mother stood up for me. She said, 'If she wants to try it, let her try it.'

"After receiving my Bachelor's degree in physics, I got several job inquiries because employers quickly looked at my name and thought I was male. However, once I went for the

interview, they offered many feeble excuses, such as that there was no ladies room, or that I would be expected to lift heavy objects—which I later found out were automobile batteries."

However, she did get a job with the National Bureau of Standards in Washington, D.C. It was there that she met her husband, who is also a physicist. They married in 1954 and had their first child three years later.

While working at the National Bureau of Standards, she attended Catholic University for a graduate degree in physics. In 1961 she had a second child and in 1963 she received her Ph.D. For two years she was an assistant research professor at Catholic University. While she enjoyed the work, it provided no security and little research support.

At this point she changed jobs to accept her current position at George Mason University, in Fairfax, Virginia. There she is a full professor of physics, one of the few women on regular faculty appointment in this field.

When asked what she likes best about what she does, she answered: "Being both a teacher and a research scientist. It is difficult to distinguish which is more rewarding. The current research work I am doing on biological molecules will be the most satisfying I have ever done.

"In teaching I like dealing with people. I get great satisfaction in recognizing students who have enormous but as yet unrecognized capabilities and in making them aware of their own abilities. I do encourage a lot of young women to enter physics, many of whom had never thought about a career in this field."

Dr. Mielczarek does all her research herself with the help of her undergraduates. In addition, she has a heavy teaching load: between nine and twelve semester hours. By contrast, most professors at large universities teach only four hours of class per semester.

Dr. Mielczarek's original interest was in low temperature solid state physics. Now, however, she is entering biophysics, as are many other physicists. Biophysics is the conjunction between biology and physics. Dr. Mielczarek is working in Mossbauer spectroscopy, applying the techniques of nuclear physics to biological materials in order to probe the molecular environment around iron atoms.

As Dr. Mielczarek explained, "Our bodies contain iron. Persons with sickle cell anemia or Cooley's anemia suffer from damaged kidneys and spleen. In these persons the red blood cells break down faster than in healthy individuals. This breakdown dumps iron into these major organs. Iron chelators, iron-grabbing compounds, are needed to clean up the excess iron. If we can understand the details of the atomic

environment of iron in iron-chelating compounds, then we are on the road to preventing damage due to this iron build-up." Dr. Mielczarek is also interested in studying model compounds of hemoglobin.

Prior to this biological research, she was a solid state metals physicist. "I have moved over into an area in which metal is in a biologic environment. Increasingly, solid state physicists are studying more complex biologic systems. Today, physicists are studying hemoglobin, cell membranes, and brain waves. This is very exciting work because it has application to living systems. Though many of us work independently, it is nice to know that our combined efforts comprise a network of knowledge that may someday lead to the cure of some genetic blood diseases."

Dr. Mielczarek has met quite a bit of discrimination in her life, but she prefers not to dwell on it since she believes that young women today need all the encouragement possible. Now, she adds, there is protection under the law. Yet, women must work hard and be better than the average men in the field, she adds.

Dr. Mielczarek believes she was able to continue her career because of her enormously supportive husband. She advises young women, "Choose your husband very carefully or do not marry at all." Her husband helped her with child care and some of the household duties were handled by outside help.

"In the beginning we were not making any money, but I wanted our children to be with a loving individual. The money was secondary. However, I never stopped working. Women who want to have careers as physicists must maintain their capability. They cannot stop their careers for full-time child

care. Part-time work is okay, but they should continue to work; otherwise, the field will pass you by."

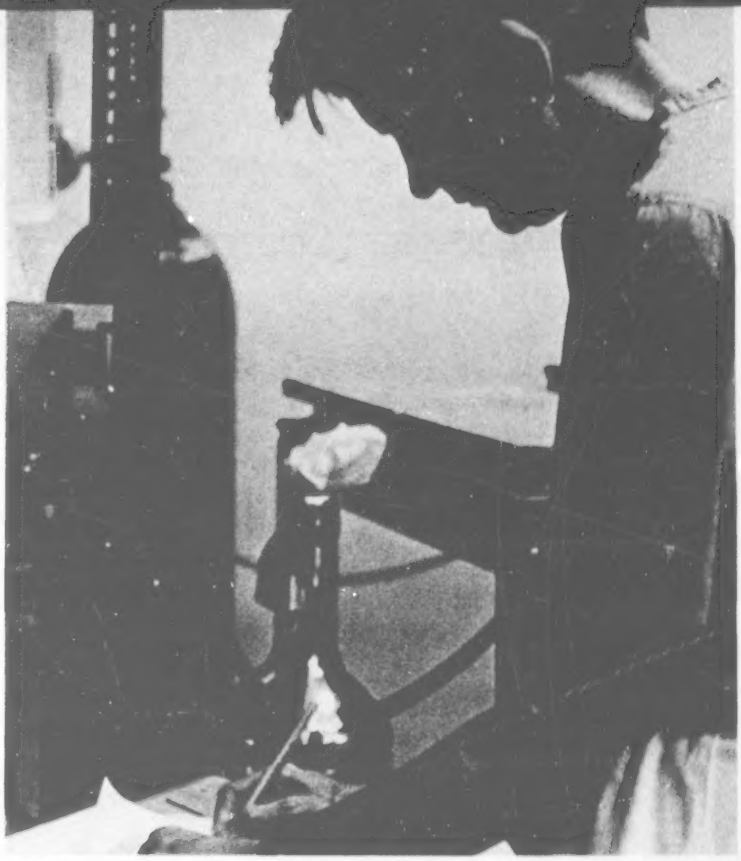
Dr. Mielczarek spends a great deal of time working, but she also enjoys many other activities. "I like music, though I am not as musical as my two children. I also like to go off in the woods by myself. I like the outdoors and especially enjoy hiking, skating, and bird watching. I also like traveling but I do not do this as much as I would like."

Dr. Mielczarek believes it is vital for young women to decide that nontraditional careers can be the path to an exciting life. She certainly feels her own life has been exciting. "Experimental physics is a field for people who like working with their hands and enjoy algebra, geometry, and trigonometry."

She pointed out there are many part-time opportunities for women in physics. There are also many opportunities for a person who has an undergraduate degree in physics. In short, "Physics is an open door to many careers."

"One woman I know with her Bachelor's degree in physics works for the State Department on ocean policy. Physicists with just a Bachelor's degree may also work in other areas of the federal or state government, such as the Patent Office or the Department of Energy."

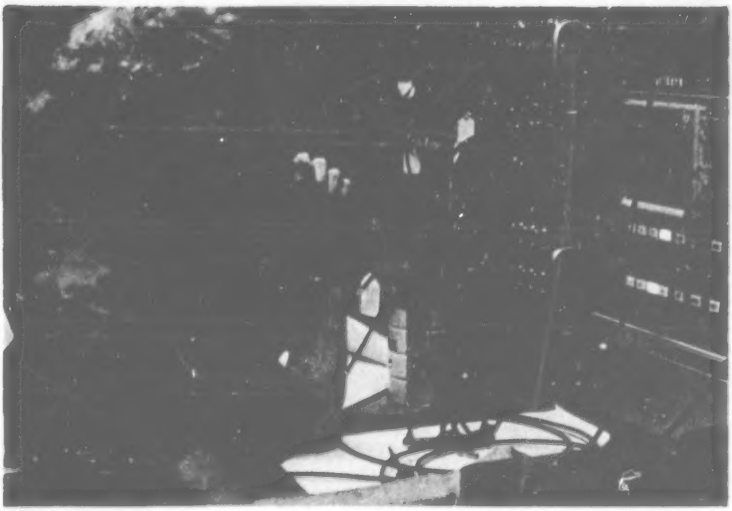
One student of Dr. Mielczarek has combined her Bachelor's degree in physics with computer science. Another former student with a Bachelor's degree is a geophysicist. Other students with Bachelor's degrees in physics may go into science writing or editing or library science. Others with a Bachelor's degree use it in technical sales or as members of research teams. In addition, physics is a strong base for an



advanced degree in engineering. Many people with their Bachelor's degrees in physics are equipped to do applied engineering.

The important thing, Dr. Mielczarek observed, is for a woman to decide to enter the field. She should set an intellectual goal for herself. She should not try to sort out everything all at once.

Finally, a young woman starting out in the field should be told, as Dr. Mielczarek told her own daughter, "Do not live your life vicariously."



DR. EVANS HAYWARD

Nuclear Physicist

"Never give up," said Evans Hayward, a nuclear physicist. She herself has never given in to defeat, although she often had cause to do so because of the limitations placed on her professionally.

She believes, however, that she has thirty years more to demonstrate to herself, to her colleagues, and to the world, some amazing things in physics.

As a child of Army parents, she went everywhere. She took math courses in high school and "always worked hard." Her

interest in physics began as a student in the Washington, D.C. schools. A woman teacher of physics lent her books and let her and another student stay after school and set up experiments. "She convinced us it was a great privilege. It was rather like Tom Sawyer getting people to help him paint his fence," she explained.

While her father was appalled at her choice of physics as her field of study, there was nothing he could do to stop her. Her mother had attended Smith College and, consequently, "She sent me there." Dr. Hayward was graduated from Smith, magna cum laude, in 1942. In recalling her college years she stated that, "I developed there a healthy disrespect for a society that could produce such intelligent girls with such limited ambition—to be someone's wife or someone's secretary. In their senior year many of them went to a private school to learn how to type. I could not respect a society that encouraged these girls with high class minds to succumb to social pressures. The concept of pursuing their own careers was foreign to them. I decided there must be another way. I did not want to repeat my mother's life of staying home and taking care of children. I did not know how to get out of this, just that I *would* get out."

Dr. Hayward recalled having no problems getting accepted at the University of California at Berkeley. She attended graduate school during World War II. Her only problem in the choice of a thesis advisor was finding a qualified person at the school; many of the professors were off in Washington, D.C., or elsewhere involved in the war effort. During the war, studying had to be conducted around the shortages of materials, supplies, and personnel.

"During the war, the physics department did not want me to escape because of the hordes of sailors who were coming to take courses. They wanted to keep me there as a teaching assistant. This meant that I taught a laboratory class every day, which is why it took me five years to earn my Ph.D." Dr. Hayward chose her thesis topic on cosmic ray physics because there was no lack of this kind of radiation, though there might be shortages of other materials.

After graduation she went to the University of California Radiation Laboratory, funded by the Atomic Energy Commission. "They had accelerators there. I did nuclear and radiation research. The problems we worked on were those we selected; our efforts were not goal-directed, organized pursuits proclaimed from on high. We got some excellent research done that way," she commented.

About this time she married her husband, who had earned his Ph.D. in physics at the University of California. Because of the prevailing anti-nepotism rule that prohibited husband and wife from working in the same department or organization, they left.

In 1950 they came to Washington, D.C., to work at the National Bureau of Standards, where they both are still employed.

Dr. Hayward's initial position at the Bureau involved working out the experiments of a theorist on the penetration and diffusion of X-rays. Then she worked with Everett Fuller using a betatron. "We were on the forefront of photonuclear physics. Now, twenty-five years later, I am still making progress in this area," she said. A photon is a quantum of light. In photonuclear physics the photon is absorbed by the nucleus of the atom and something else emerges.

To conduct her experiments she needs an accelerator, detector, and target. Her current work is mainly involved with gamma ray scattering. With a smile she explained, "It has no practical application, though at one time an oil company approached me about the strong transition of carbon 12 that may be used to find oil." However, she said, since she has not heard from the company in a number of years, she presumes this proved impractical. Her concern and that of other scientists is, "in pushing back the forefront of science."

Dr. Hayward has also contributed to the work of other institutions throughout the western world. In 1961 she was a Guggenheim Fellow while a guest of the Institute for Theoretical Physics in Copenhagen. She also served as a guest professor at the Institute of Nuclear Physics of Goethe University in Frankfurt am Main, Germany, in 1966. Then in 1969 she was the Sir Thomas Lyle Fellow at the University of Melbourne, and in 1975 she was a visiting professor of physics at the University of Toronto. She is currently planning another trip to Germany, where she has been invited to present a paper.

Ironies abound in her career. Ten years ago she said she would have considered a career in management; then it was not available. Today, she believes, because she is a woman, a management opening for which she would be eligible may be offered to her. However, this is not the path she chooses to follow. She is, "too curious about what there is to learn in science from theoretical physics."

Despite the problems and setbacks, Dr. Hayward has served on several important scientific committees. A few years ago she was chairman of the Maryland Committee on Energy. An even greater honor was her nomination to serve on the General

Advisory Committee of the Atomic Energy Commission. "I learned a lot from this high-powered group," she said. "It met four to six times per year in various atomic energy facilities. Topics for discussion included basic research, lasars, isotopes, and inspection of facilities. Members of this group not only talked about problems, they also wrote reports. Dr. Hayward believed this was an important stage of her career because, "I got to meet and become friends with erudite, important people I would never have known otherwise."

Dr. Hayward considers her life pursuits, "fairly single-minded." However, she does read novels and attends plays and concerts. She and her husband own their own home in a suburb of Washington, D.C., where they raised their two sons.

While she was working, "we hired someone to babysit. Having a full-time sitter was expensive, but it allowed us to go away and leave someone with the children. Even with two salaries there was little extra money and what there was went for such expenses as taxis for the children to take them to after-school activities. In pursuit of a career you have to sacrifice many things," she said.

She returned to work six weeks after each child was born. She had her children during "sick leave." However, even during these weeks colleagues called her and came to talk business. "I did not stop," she emphasized.

Dr. Hayward believes it is a great mistake for anyone serious about her career to drop out for any reason. Physics develops rapidly and if you do not keep pace, you might as well start over from scratch. This is very sad, she said, recalling a number of her friends who did drop out to raise families.

"I could not have had my career and raised our sons without my husband," she said. "Do not marry someone who is resentful of you or thinks you should stay home. I have been lucky. My husband is great."

In addition to her husband's support, she has some female colleagues in related fields who bolster one another. Also, there are now some formal groups where women in the National Bureau of Standards and the Commerce Department can meet to discuss problems of concern.

Dr. Hayward is the recipient of several awards: the Department of Commerce silver medal, 1958; the Department of Commerce gold medal, 1971; and the Federal Women's Award, 1975. She is also a member of Phi Beta Kappa and Sigma Xi, a fellow of the American Physical Society, and a member of the American Association for the Advancement of Science.

Dr. Hayward has written and published a number of papers in her field. She looks forward to continued research so she can learn new things and communicate them to others.

CHAPTER 6

MATHEMATICS

Mathematics is useful in and of itself and increasingly useful in conjunction with other scientific fields. While some areas of mathematics have an oversupply of trained personnel, other areas lack qualified people.

Mathematicians are in great supply at universities and colleges. In the following general areas there are a considerable number of openings for people with mathematical backgrounds: computer science, operations research, statistics, the actuarial profession, and interdisciplinary areas. Much of a woman's chance to get a job in this field depends on her training and background.

About 47 percent of all mathematicians work in elementary and secondary schools, junior and community colleges, and four-year colleges and universities. In 1977 a distinguished university paid a beginning salary of $15,700. Generally, however, the starting figure was $14,100.

Many mathematicians are employed by the government. About 22 percent of the mathematicians employed by the government are women. The mathematician who works in industry is generally part of a team. "Thus a fundamental requirement is the ability to communicate problems that are poorly formulated by people with limited mathematical training," according to the Mathematical Association of America.

The type of job you are seeking will influence whether you major in math per se or in a related mathematical science, such as computer science.

According to the Bureau of Labor Statistics, in 1974 there were 14,000 mathematicians employed in the United States. By 1985 the Bureau of Labor Statistics predicts there will be 23,200, but there will only be a demand for 16,000, resulting in a surplus of 6,500 or 28 percent. The National Science Foundation arrived at slightly different figures, but predicts a comparable surplus of 5,600 people in mathematics by 1985.

Seen another way, the Bureau of Labor Statistics reports that each year an average of 19,205 students graduate with a Bachelor's degree in mathematics, and an additional 5,871 earn an advanced degree. However, there are only 1,550 annual job openings. Obviously, many math majors must find jobs in related fields.

Some people with only a Bachelor's degree can get jobs in industry or government. More interesting jobs require at least a Master's degree. Some corporations will pay for your continued schooling—a very important fringe benefit. Some corporations, as well as some government agencies, offer internships to college students. Most college and university teaching positions now require a Ph.D.

Operations research is one of the newer mathematical fields. While it grew out of military research in World War II, it now encompasses both business and academic problems. Positions offered in this field include operations analyst, systems engineer, or systems analyst. Operations research is utilized in many ways, including the planning, programming, and budgeting of the United States government. It allows quantitative analysis and comparison of competing programs. The Mathematical Association of America described a sample problem concerning the optimum operation of toll booths on a

bridge or turnpike. The problem is to achieve the best balance between having idle attendants during slack hours and too much delay during rush hours. To solve the problem, one would have to determine the statistics of the traffic flow, construct a mathematical model of the queuing system, and determine the expected number of idle attendants and the expected delay as a function of the number of attendants. The resultant expression would then be analyzed to determine the optimum performance given any other restraints imposed.

A limited number of opportunities are available for a person with a Bachelor's degree in operations research, but most people in this field tend to have at least a Master's degree. Operations research can help solve a variety of problems in different fields. Over 10,000 companies are devoted to operations research consulting, and consequently there is a heavy demand for operations researchers.

Actuaries comprise another professional group open to mathematicians that is currently much in demand. An actuary is a professional who is expert at designing insurance, annuity, and welfare plans of all kinds. About 60 percent of all actuaries work for insurance companies.

In the fields of life and health insurance and pension funding, the Society of Actuaries administers a series of nine examinations by which an actuary's abilities are measured. The more tests passed, the greater the individual's opportunities for advancement. The Casualty Actuarial Association administers examinations to actuaries employed in other areas.

According to the Mathematical Association of America, a number of women have distinguished themselves in actuarial

careers. The Society of Actuaries, located at 208 South LaSalle Street, Chicago, IL 60604, administers a special graduate school scholarship fund for women and minorities.

In 1978 the median starting salary for actuaries who had not taken the total series of examinations was $12,500, and for those who had passed four or five examinations the salary rose to $16,500. Most actuaries can hope to triple this base during their careers. Many actuaries assume senior management responsibilities in their organizations.

Another growing mathematical area is information science. The information scientists may also be called control systems analysts, communications systems experts, or signal processors. The information scientist transforms speech into various electrical signals suitable for transmission over telephone cables, radio broadcasts, or for digital transmission by satellite relay. Most telecommunications areas are growing, as are other forms of information storage and retrieval, to maintain business records and accounts, automated libraries, and data banks. Another application of information science is to recognize patterns in geophysical records useful in the location of petroleum deposits.

Another growing field in mathematics is statistics. Statisticians give advice on the statistical design of experiments, conduct surveys, and analyze data with the help of existing statistical techniques or by devising new methods of analysis. Increasingly, they use computers. Statisticians generally collaborate with specialists in other fields such as agriculture, biology, economics, psychology, sociology, business, law, and industry. And with such a wide range of areas in which to work, you'd be correct in assuming that there are opportunities

aplenty in statistics. This is especially true in nonacademic areas, most notably in chemistry and pharmaceutical or biomedical research. Here there are many jobs for people interested in working with applied statistics. And for people who have a strong computer background, the sky is the limit. Dr. Joan Rosenblatt, Deputy Director of the Center for Applied Mathematics of the National Bureau of Standards, explained that her department had been trying to hire computer experts and had a hard time because there are reportedly twelve jobs for every qualified applicant.

The education and training required for a background in statistics varies. Few schools offer a Bachelor's degree in statistics. However, some employers such as Bell Telephone Laboratories in New Jersey, the Census Bureau, Washington, D. C., and the National Center for Health Statistics, do hire people with a Bachelor's degree in mathematics and then train them in statistics.

"A Master's degree is almost basic, however, for most jobs. A Ph.D. is required for most academic jobs and it's a near-essential for many government jobs as well. Yet some industrial companies consider a candidate with a Ph.D. overqualified. Often, this is the result of a mismatch between an individual's academic training and the job expectations of employers," Dr. Rosenblatt said.

In statistics there is no end to the jobs available to you. You can work for business in economic forecasting, marketing, or quality control of manufacturing; or you might work for a nonprofit institute conducting economic or social research; or you might find employment with a public opinion polling organization.

A great deal of statistics work is done in collaboration with other disciplines. Dr. Joan Rosenblatt, a statistician profiled later in this chapter, had an undergraduate minor in physics. This helps her now when she works with physicists. For example, once she had to learn about the psychophysics of color vision. By the time she was finished with the project, she not only could read and understand articles in the *Journal of the Optical Society of America*, but had co-authored one of them herself.

To be a success in statistics, you must be interested in acquiring information on a variety of fields. Statistics is often taught in conjunction with economics, psychology, and industrial engineering; sociologists are often encouraged to take it. Computer programs make it easier to do the required calculations, but you must understand how and why such calculations are being done.

Statistics is a good field for people who desire to work part-time or who want to take some time off during their career. "You do not get obsolete as fast as in physics or chemistry. However, you need to keep the skills at your fingertips," Dr. Rosenblatt noted.

It is not easy to find a part-time job as your first job. It is much easier if you have worked full-time first. The National Bureau of Standards has been receptive to part-time employees. Some other agencies have not been as receptive. Women with computer programming experience can find good part-time jobs.

Economically, statisticians fare better than most other mathematicians. Each year an average of 257 people earn Bachelor's degrees in statistics, and 600 people earn advanced

degrees. Yet, there are 1,450 openings per year in this field.

In 1977, newly-graduated Ph.D.'s earned approximately $14,000 for an academic year of college teaching. Full professors earned between $20,000 and $40,000 per year. Some private consultants in this field earned over $50,000 per year.

By contrast, economists do not fare too well. The Bureau of Labor Statistics reports that each year an average of 13,972 students earn Bachelor's degrees in this field, and 2,932 earn advanced degrees. They compete for 4,700 annual job openings.

The College Placement Council said 1977–78 beginning salaries for male Bachelor's graduates in mathematics were around $13,000, while for females they were $11,500.

The National Research Council said in 1970–71 women earned 7 percent of the Ph.D.'s in mathematics and in 1976–77, they earned 13.3 percent. In math sciences the unemployment rate of women who earned their Ph.D.'s in 1977 was 3.2 percent compared to men with a similar background whose unemployment rate was 1 percent, the National Science Foundation reported. At the baccalaureate level, the unemployment rate for women was 5.7 percent compared to 7.3 percent for men.

A number of mathematical associations offer career information and/or placement help. One group, the Association for Women in Mathematics, lists job opportunities in its newsletter and has a job registry for members.

DR. JOAN ROSENBLATT

Statistician

"Women have never found it easy going in any professional area but quite a number of women work in statistics," said Dr. Joan Raup Rosenblatt, Deputy Director of the Center for Applied Mathematics at the National Bureau of Standards (NBS).

The incoming president of the American Statistical Society is a woman, and she is not the first. In fact, one of the founders of the British Royal Statistical Society was Florence Nightingale.

Nevertheless, the situation for women in statistics is not ideal, especially in universities. Here, and also in other areas, women statisticians tend to earn less than males. Recently, however, the statistics profession has become very conscious of women.

Dr. Rosenblatt does not recall many blatant instances of sex discrimination against her. Her work has taken her to many laboratories at the National Bureau of Standards, but as a safeguard against prejudice she recalls that, "if I had an intuitive sense that I was not taken seriously, I sometimes took along a male colleague. But my rate of advancement has been faster than I expected, so I have no complaints on that score." Dr. Rosenblatt is also proud of the fact that her recognition by professional societies began before the push for women's rights. This way she said, she feels satisfied that people usually want her not because she is a woman but because she is an astute statistician, a fact formally acknowledged in 1971 when she received the Federal Woman's Award and again in 1976, when the Department of Commerce presented her with a gold medal.

Dr. Rosenblatt's office at the National Bureau of Standards is cluttered. An abstract oil painting hangs on one wall; on the windowsill there is a small potted plant; the chalkboard is filled with equations. On another wall hangs a plaque given to her by the Korean Standards Research Institute. Dr. Rosenblatt has a strong handshake. Her voice is resonant; her movements are decisive.

In a 1977 speech at an American Association for the Advancement of Science conference she described her work at the National Bureau of Standards:

"The National Bureau of Standards is a research laboratory in the physical and engineering sciences that consists of a large collection of small, highly specialized labs where research in selected areas of physics, chemistry, and engineering is conducted. Day-to-day work is discipline oriented. Most members of the scientific staff identify themselves as atomic spectroscopists, or electrochemists, or combustion engineers, or algebraists, and judge their work by the criteria of such specialized communities.

"The National Bureau of Standards has a mission. Specific responsibilities Standards by acts of Congress. The Bureau maintains and disseminates the basic units of measurement—mass, length, temperature, frequency, and electrical units. These are the basic inspectors. It also establishes the basis for the uniformity of measurement that makes mass production in industry or air pollution regulations possible, and it is the key to comparability of results in experimental science. The National Bureau of Standards is also responsible for providing scientific and technical services to other federal agencies and to industry.

"Senior scientists and especially the management (of which I am a part) have to consider national needs in choosing among programs and projects. It is not enough to say it would be exciting to have a transmission electron microscope; but it can be argued that is it important to have one in order to meet the needs of regulatory agencies for accurate characterization of submicroscopic asbestos fibers. Then come hard questions; for example: Is this need as urgent as the need for improved

low temperature measurements for increasing imports of liquefied natural gas? In the long run, the hiring of research staff is based on this kind of balancing," Dr. Rosenblatt explained.

"Now, what is the role of mathematical statistics in this research environment? Fundamentally, statistical theory provides an orderly way to evaluate measurement errors. We have a vocabulary, since Gauss, of mathematical models for representing the irreducible variability of results that comes with any actual realization of a physical theory, and we have concepts of experiment-design and techniques for data analysis that are helpful in achieving sufficiently accurate results.

"The Statistics group at the National Bureau of Standards, which I now head, provides statistical consulting services to all parts of the Bureau, and also researches improved statistical methods for applications in physical and engineering sciences.

"I came to the Bureau after writing a thesis on the theory of nonparametric statistics, especially rank-order methods like rank correlation. This background was put to work in collaboration with the Bureau's program in the physics and psychophysics of color measurement. The human eye is a very good color detector. There is an interesting mathematical theory relating physical measurements of the wavelength of light and the intensity of radiation to the empirical observation that all colors can be produced by mixing three primary colors. The experimental data for making this theory quantitative come from judgments—rankings or comparisons—by human observers. The results of the National Bureau of Standards' experiments, and similar experiments in England and Russia, made it possible for physical measurements to be used to

predict color matches for the paint and cosmetics industries, and to specify safety colors for school buses and airport lighting.

"The National Bureau of Standards' color measurement program matured and phased out some years ago; yet, similar statistical problems are appearing in a growing program on the physics and psychophysics of sound and noise measurement—how to characterize the noisiness of cars and trucks, lawn mowers and home appliances, not to mention construction machinery and rock bands, so that standards and regulations can be written to protect hearing.

"The research problems that I have been most concerned about in the last few years arise from the proliferation of new federal regulations, all resulting from acts of Congress—regulations based on physical measurements of such things as water, air, pesticides, noise, radiation, occupational health and safety, and transportation safety.

"A swarm of statistical problems is associated with these regulations. Can it really be demonstrated that sulfur dioxide concentrations are accurately measured? When regulations are written, how much allowance should be made for measurement errors, and who should benefit from the allowance for measurement error? One of my chief concerns is that the nation's measurement standards should serve the public need for fair and impartial regulation. And I see an important role for research in mathematical statistics toward this end.

"I believe any career scientist in a federal laboratory would tell you that there are exciting challenges, especially for a research worker who wants to ask herself, from time to time, 'Why am I doing this?' For myself, I can answer that I satisfy my scientific curiosity at the same time that I feel I am contributing to public service," Dr. Rosenblatt noted.

Dr. Rosenblatt's choice of a career in mathematical statistics came easily. Her mother was a professor of economics at Barnard College. "She was among the first to promote the study of consumer economics." However, Dr. Rosenblatt reflected, while her mother taught economics and statistics, "she raised four kids too. She was a popular teacher and adviser of students, but did not have time to publish much." Dr. Rosenblatt remembered her father's keen awareness that his wife did not get all the professional recognition she deserved.

Dr. Rosenblatt grew up in the atmosphere of a family that stressed education. She attended Barnard College, where she received her Bachelor's degree in mathematics. After this she was appointed to a National Institute of Public Affairs internship in Washington, D.C. During her nine-month stint, she

worked first in the Office of the Assistant Director for Statistical Standards of the Bureau of the Census and then in the Division of Statistical Standards of the Bureau of the Budget.

During World War II, statistics took on new applications in physics and engineering science. The war-time applications helped broaden the scope of statistics and it has expanded since. One group interested in the expansion and use of statistics is the International Statistical Institute; a group to which you must be elected to become a member. Dr. Rosenblatt, in her modesty, only casually mentioned that she had become a member a few years ago. Her first job was to help coordinate an International Statistical Conference, the first to be held after World War II. She enjoyed this work, particularly the management and the political problems it entailed—at least one of the best statisticians was a fascist. She recalled the parties associated with this conference and the White House reception for it she attended, as well as the special visits with her mother, who attended as one of the official American delegates.

After this she attended graduate school at the University of North Carolina at Chapel Hill. Even though she was the only woman in her student group, she felt, "very unself-conscious. I had no problem in picking my thesis advisor," she remembers. She claims she had been procrastinating about taking her oral examination while planning to get married, and the department chairman told her she was to take it in two weeks and she needed a thesis advisor. So, she went into a professor's office and simply asked him. He agreed.

In Washington, D.C., Dr. Rosenblatt had met her future husband, David, who is a mathematician. For one year they

lived in Pittsburgh. Then her husband moved back to Washington, D.C. So while she was finishing up her degree, she commuted between Washington, D.C., and Chapel Hill.

After she received her Ph.D., she came to work at the National Bureau of Standards in the applied mathematics area. She began work in the Statistical Engineering Laboratory in 1955. In 1963 she became assistant chief, and was then head of this unit from 1969 to 1978. In 1978 there was a reorganization and she became the Deputy Director of the Center. She holds a high government rank of GS-16, which she has held for more than seven years.

Dr. Rosenblatt is active in many professional societies. She is a member of the editorial board of *Communications in Statistics*. In the American Statistical Association, she is a past chairperson of the Section on Physical and Engineering Sciences, and now sits on the Board. She recently completed a three-year term as council member of the Institute of Mathematical Statistics. She has also served in various editorial and committee posts of these organizations and in the Society for Industrial and Applied Mathematics. She is also a past president of the Caucus for Women in Statistics.

There are many statistical questions in the public area where physical measurements are involved; for example, environmental regulations limit the type and amount of industrial waste that can be dumped into the nation's lakes and rivers. Samples of the wastes are taken and chemical analyses of the contents are made. However, it's a fact that replication of these experiements would most probably yield different results. Part of this difference comes from statistical sampling errors and part may result from errors in the analytical procedure, Dr. Rosenblatt explained.

"Measurement is not an absolute fact—there can be measurement errors," she cautions. "Nonetheless, the environmental regulations are based on our ability to measure the effluents. There are major questions about regulating other things difficult to measure, such as chemical additives for food that the Food and Drug Administration handles under provisions of the Delaney amendment, which bars additives to food known to cause cancer. The better you can measure, the more you can find," she noted with a smile.

Dr. Rosenblatt also relates how statistics is used to solve other social problems. She has co-authored a paper on "Randomization and the Draft Lottery." This paper explained how the Selective Service System asked the National Bureau of Standards to prepare twenty-five random calendars for use in connection with preparations for the draft lottery conducted July 1, 1970 to determine the order in which men born in 1951 would be called for induction into military service.

This random selection method required painstaking efforts, carefully thought out, checked, rechecked, and checked again. If the United States returns to a draft lottery the random methods developed by Dr. Rosenblatt and her colleagues could again be used.

"The principles of randomization are basic to statistics," Dr. Rosenblatt said. "For example, in agriculture, when someone is testing several fertilizers, a field trial is needed. The field is divided into plots. All parts of the fields are not exactly alike, so to avoid bias in your treatment of plots, you assign plots at random, but there must be at least two plots for each chemical tested. Then you assess the average differences between chemicals, as compared to the differences between the

pairs of plots similarly treated. Such methodology is the concern of all experimenters, including those doing opinion polls and sample surveys," Dr. Rosenblatt said.

Dr. Rosenblatt works hard. However, she does have time for reading, cooking, and going out to dinner with friends. She is an omnivorous reader of fiction and nonfiction. Her preferences include classics, biographies, and books on public affairs and science, as well as technical publications. In the evenings she laments that, "By the time I have listened to the news, made dinner, and done a little work, it's time for bed." She lives in an apartment in the District of Columbia and commutes to the National Bureau of Standards in the suburbs. Dr. Rosenblatt and her husband have no children.

When asked about her future plans, she thought and said, "I am having a fine time where I am right now." She is not seeking to make changes in her career. "It has worked out pleasantly and this is a fascinating job."

CHAPTER 7

COMPUTER SCIENCE

As our information needs grow, computers will play an increasing role in business, industry, education, the professions, scientific research, and recreation. And as computers increase in number and versatility, more people will become involved in this area. More people will be needed to design and build computers, to analyze problems and devise solutions using computer technology, and to convert information into data that can be used by the computer. In addition, other people will be needed to work in other facets of the computer industry, including engineering, sales and marketing, and customer service.

Demand for computer scientists will continue at a high level as more and more computers are placed in operation. In 1975, there were approximately 100,000 general purpose computers in use in the United States, supporting a work force of approximately one million persons involved in work relating to computers, in computer organizations, in firms using computers, and in computer services. With the number of computers expected to double by 1980, needs for personnel in many key areas should also double.

The computer labor force is expected to grow at a rate approximately 40 percent higher than that for the nation's total employment and reach more than 1.1 million by 1985. Demand will be greatest for systems analysts, programmers, and equipment operators.

Most individuals within this field will be employed by service-oriented organizations such as manufacturing, banking, finance, insurance, real estate, data prccessing services, wholesale and retail trade, and computer manufacturing, according to Thomas C. White, of the American Federation of Information Processing Societies, Inc.

The two essential ingredients in electronic data processing (EDP) are the computer and computer-related equipment, known as "hardware," and the assembled instrumentations, or "software," which enable the computer system to perform its tasks.

In its simplest terms, a computer installation consists of a system of devices for the input of data and information into the system: a "memory" section used to store data, information, and instructions; a central processing unit where the data and information is processed in accordance with the stored instructions; and output devices which make the processed information or "answers" available to us.

Fundamentally, computers are capable of two simple arithmetic operations—adding one number to another and comparing two numbers to see if they are equal. They produce answers only as good as the data and instructions given them.

A wide range of people are involved in using computers. They include:

- Operators of auxiliary equipment directly associated with the computer; tape librarians and handlers; keypunch operators; and clerical assistants. (Most of these positions tend to be low-paying and are filled predominately by women).
- Machine operators feed the data into the computers and control their operations.

- The console operator reviews computer programs and instruction sheets and determines the equipment setup for each job. The operator investigates and corrects stoppages, and calls for any required maintenance. In addition, the operator keeps a log of work done and prepares reports on computer use.
- Programmers prepare the instructions that tell the computers how to handle information and solve problems.
- Systems analysts develop methods of using the machines to solve problems.
- Sales representatives and systems engineers find new uses and users for computers.
- Engineers and technicians produce the equipment and then maintain it.
- Scientists, mathematicians, and engineers research, design, and develop computers and related equipment.

Obviously, some jobs require a college education. For other positions, a college degree is very helpful but not essential. For still others, no formal education beyond high school is required.

The American Federation of Information Processing Societies, Inc., has described the duties and responsibilities of programmers and systems analysts as follows:

"The programmer's job is to devise a detailed plan for solving specific problems or types of problems using the computer. This plan is called the "program" and in final form it consists of a series of coded, step-by-step instructions which make the computer perform the desired operations."

Programmers also check and "debug" their programs to make sure they are free from errors. They do this by prepar-

ing sample data and testing it on the computer and then by making trial runs with data from the actual project.

Programmers often work as a team, with different levels of responsibility. Depending upon the project, there may be a programming manager or a senior programmer assisted by a staff of programmers, junior programmers, and trainees. While experienced programmers can write programs for many different types of problems, they frequently specialize in one of three areas: scientific applications programming, business applications programming, or systems programming.

In order to write computer instructions to solve engineering and scientific problems, the programmer must have a sound knowledge of mathematics and the basic principles involved in areas relating to the program. A college degree is required and an advanced degree is desirable.

A business applications programmer must be able to deal with a variety of problems, different types of computers, and various computer "languages." These requirements demand a high degree of ingenuity, experience, imagination, and above all, the ability to think logically. While such a programmer is often called upon to handle routine business tasks, other problems encountered be as complex as those in scientific fields. For business applications, a college degree is not always essential. However, it is most helpful and its equivalent may be required for continued advancement into a management position.

People who write instructions that make it easier to program computers and put them to work are called systems programmers, to distinguish them from those who develop applications programs.

A systems programmer might help write an operating system involving a series of complex programs. Such programs schedule and allocate the various components of the computer, handle priorities, keep track of what is going on, and permit a large computer to deal with many tasks simultaneously.

Based on the user's requirements, systems analysts help devise efficient patterns of information flow from its source to the computer. The analyst also defines the computer process necessary to turn raw data into useful information, plans the distribution and use of results, and checks out the working system in operation.

While a formal educational background in business administration is helpful for systems analysts who specialize in business data processing, it is not always required. Business experience plus the ability to reason logically are critical. However, many employers do require that systems analysts have two or more years of programming experience plus a college degree.

The College Placement Council reports that average beginning salaries for males with Bachelor's degrees in computer science in 1977–78 were $15,900; for females they were $15,700. Top offers to graduates with Master's degrees in computer science were $18,432.

Salaries in the computer field are generally above average. However, salaries vary according to an individual's background, the type of computer used, the nature of the employer, and the geographic area.

In general, computer operators earned between $11,000 and $15,000 in 1979. Programmers earned between $14,000 and $19,000; systems analysts earned between $16,000 and

$24,000; and data processing managers earned an average of $25,000, according to a 1979 report by the American Federation of Information Processing Societies, Inc.

As the following table shows, except for the lowest paid category of keypunch operators, women constitute 20 percent of all the occupations in computer-user industries. Within these occupations, women tend to be employed in fields with lower requirements and lower skill categories.

1970 Census Data on Computer Users

	Male	*Female*	*% of Women*
Keypunch operator ...	27,896	244,674	89.7
Tabulating machine operators	4,118	4,062	49.5
Computer Operators ...	83,023	34,199	29.2
Programmers	124,956	36,381	22.6
Systems Analysts	68,213	11,736	14.7
Other Computer Specialists	11,445	1,806	13.6
Data Processing Repairers	30,844	864	2.7

On the average, in this field women are paid less than men. However, while most women in this field believe that pay levels are comparable between the sexes, they do recognize that their chances for advancement to higher levels of management are less than those of their male peers.

As one of the women put it, "Men do not think about promoting women. Many women have chosen to change jobs rather than to stay in one place and fight discriminatory nonadvancement."

KAREN THOMANN

Computer Programmer

Becoming a computer programmer was a natural step for Karen Thomann. All her life she has had an interest in the way things happen, their logic and sequencing.

While growing up in White Plains, New York, she attended a private high school and took three years of math. She enjoyed it. She had no firm career plan at this early stage and toyed with becoming a French major or a music major, since she had taken twelve years of piano lessons.

While she attended Fordham University in New York City, she majored in philosophy. After graduating with a Bachelor's degree she decided not to continue her philosophy major directly, but to use it to pursue a subject area where problems were solved logically. She entered the University of Massachusetts School of Education in 1972, but Ms. Thomann knew she did not want to teach, and she also realized that too much reading or too much writing bored her. So, she sought instead something known as "logic and systems," part of a field called methodology.

She wrote her Ed.D. thesis on methodology. "This involves writing up a set of procedures. It is similar to writing a program in the computer field and debugging it," she explained.

"When you write a program, a computer follows it. Methodologies are procedures which people follow, but they must be generalized so they work in different situations. An

individual must program only within the limits the computer is ready to understand."

Ms. Thomann field tested several concepts in methodology. This involved arranging a test and writing up the results. The thinking pattern she employed is similar to what she is currently doing in computer programming.

For about eighteen months she was employed as a research assistant at the Student Affairs Research and Evaluation Office at the University of Massachusetts. She was director of Project PULSE, a telephone survey project organized to provide university officials with immediate student input. A random sample was polled on different topics every week.

From there she moved to Columbus, Ohio, to work as the acting coordinator of the assessment/evaluation unit of the Office of Student Programs and Development of Ohio State University.

When she received an offer to move to Washington, D.C., to work for the American Bankers Association, she accepted it. She served this association as an evaluation specialist in educational policy and development.

She entered computer programming after completing her doctorate in education because education jobs were scarce and there was much competition. "I was not so enamored of the field of education that I had to stay in it. I looked for another application of methodology." Since she had taken some training in college, programming seemed to her a viable career option.

She decided to attend a proprietary (for-profit) school to get more in-depth training in computer programming. She chose the Computer Learning Center in Virginia because she knew

some people who had attended there and also knew that the school offered placement help.

Ms. Thomann has nothing but the highest praise for the education she received there. "I learned about as much in the intense training of three weeks as I had learned during a full semester at college about the Fortran IV programming language." She recommends that people interested in computer science attend trade schools for training because their only mission is to train people for jobs. "They are not interested in providing people with a broad liberal arts background. They offer training rather than education. This is especially critical if one already has a college background." Many of Ms. Thomann's classmates were also college graduates seeking to upgrade their skills and education with specialized, job-related training.

"Computer programming is an excellent area for college-educated women to consider," Ms. Thomann said. It is also an area that may appeal to women who have been out of the labor force for a number of years but who previously had training in science, mathematics, or other related areas.

Women who are considering training at a trade school should check out the school's reputation with people they know who went there. One way to check on the reputation of the school is to contact computer programming firms and ask them if they would hire graduates of this school or from what schools they have hired people. She suggested that another crucial reason for choosing a school is the type of placement it offers. Under new Federal Trade Commission regulations, proprietary schools are required to reveal their placement rates for graduates.

Ms. Thomann was placed by her school in her current job as a computer programmer with Sage Systems, Inc. The company is housed in a luxury apartment building in Bethesda, Maryland, minutes from downtown Washington, D.C. Ms. Thomann has her own office, though she can do much of the planning of programs at home. During a recent winter, she rarely came to the office, spending long hours figuring out programs at her home. The only reason she needs to be in the office is to run the program on the computer.

Ms. Thomann is pleased with her work and with the company that employs her. "This company is unusual in that once you prove yourself, they tell you to progress as fast and as far as you want. The company works on a contract basis. They write programs for other companies using the computer programming language they have developed and refined."

Ms. Thomann explained, "I began working in applications. This means writing programs to solve very specific problems in payroll, inventory, and so on. Later I was promoted to software programming. This is programming at a level where the purpose is to solve problems of a more complex nature. Software programmers write programs that help the application programmers write their own programs, as well as do programming themselves."

"I am in my element when I can solve problems logically. I invent ways of writing codes to solve problems, which demands that I know what to borrow from other things I have done. This involves piecing things together and testing new solutions. I like the challenge of being left to my own devices to come up with solutions. . . . I thrive on problem solving."

Some of the drawbacks of the job concern worries about complex problems. "I have some downs," Ms. Thomann

admitted. "The nature of the work can be frustrating. When you have doubts about your ability to solve a problem, you have a drop in motivation," she explained.

Ms. Thomann works hard, often far beyond a nine-to-five schedule. When she is not working, she enjoys figure skating or ice dancing. She also loves music and still enjoys playing the piano. On Saturdays she likes to go window-shopping and buy clothes, as she enjoys keeping up with the latest fashions.

Ms. Thomann believes that computer programming is a good field to get into. "Companies are increasingly automating their processes," she observed, "and this will keep the computer field growing." But Ms. Thomann warned that not all jobs in the field offer advancement opportunities as good as hers. Many jobs, especially those with large companies, tend to be dead-ends. Because of the cost and difficulty of installing any new system, many companies stay with their own system and code. This does not allow the programmer the freedom to develop new ideas or systems.

"An individual may also combine computer science with another science career and become an extremely salable commodity," Ms. Thomann pointed out.

CHAPTER 8

EDUCATION AND FINANCIAL AID

The first steps toward becoming a scientist occur in high school. A young woman must be sure she has at least a three-year mathematics sequence.

It is also advisable for potential women scientists to take mechanical drawing, electronics, and other machine shop courses. Often, experiences in shop courses compensate for many young women's inexperience in working with tools. Shop experiences are also good background for laboratory courses in college, where women have to know how to handle equipment and what to do in case of equipment failure.

Though shop courses have traditionally been restricted to males, Title IX of the Higher Education Act specifically prohibits public schools from not allowing women to take any course that is open to men. In fact, part of this law compels counselors to provide nonbiased counseling for girls and women with regard to courses of instruction and vocational planning. Yet, many young women are still discouraged from taking advanced mathematics courses or shop courses.

As a consequence of the government's failure to monitor Title IX adherence closely, a private group performs such monitoring. This group is PEER, Project of Equal Educational Rights. PEER, located at 1110 Vermont Avenue, N.W., Washington, D.C., is anxious to hear about educational discrimination against women.

After high school, at least four years of college is required for careers in science. Most women point to the necessity of

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attending the best school to which you can gain entry. While it may be cheaper to attend the local community college for the first two years, this will hurt your chances of getting into a prestigious four-year university later. Obviously, financial considerations come into play here too. Young women should definitely plan their financial route to school early in their high school careers, certainly by their junior year. See the following section on financial aid for further details.

One woman scientist said that attending the wrong school will hold back your professional career by ten or fifteen years. This is true because of the valuable associations and contacts one makes in prestige universities.

In most fields a Bachelor's degree is not sufficient for anything but the routine tasks. However, this is not so true in fields where there are greater numbers of employment openings, such as computer science. But in many fields, women with their Bachelor's degree in science may earn less than secretaries. And, unfortunately, many women who have a Bachelor's degree in science get discouraged and become secretaries.

A solid science background at the Bachelor's degree level provides the necessary base for a Master's degree. Several women scientists have suggested that women take rigorous science courses in the hard sciences, chemistry and physics, rather than more general, broad-brush science courses in the soft sciences, such as ecology and the social sciences. A background in the hard sciences may easily combine with the soft sciences and lead to interesting employment later on. As jobs change, people with a hard science background can restructure their training to do a variety of jobs. Many of the women whose stories are here are proof of this.

A 1978 study, *Report on the Participation of Women in Scientific Research,* has shown that more women than men obtain their Master's degrees. However, more men than women earn Ph.D.'s. There may be a number of reasons for this.

One reason may be a woman's reluctance to go into debt to finance her education because making less money than her male counterpart means more difficulty in repaying her loans. Another reason may be the conflict between career and family. Also, for many women who must juggle both career and family, the Master's degree often provides more immediate and certain job security than the Ph.D.

The report also found that about twice as many women as men switched fields between their Bachelor's degrees and their Ph.D.'s. This may be a result of stepping out of the work force for a while and gaining a perspective on what sort of career they really prefer, or it may be a result of women not finding jobs in one area and switching areas to maximize their employability. Obviously, if you switch careers or fields, it will take you longer to become established.

A growing area of employment is postdoctoral research. This position normally lasts for a year and permits a woman time to earn some money and be in a scientific atmosphere where she can do some of her own experimental work. A recent study has found that women hold postdoctoral fellowships more frequently than men, and often held them for over a year. One researcher suggested that women get more postdoctoral positions because they receive fewer permanent employment offers. Yet, even in this area, the mean annual stipend awarded the men was slightly higher than that of the women.

One of the purposes of this book is to encourage young women to enter science. Nevertheless, they should know that science is a rough area for a woman. Yet women have succeeded, and despite great odds there are many women scientists at work today. While some of the discrimination is lessening, it is far from gone. At recent conferences on women in science, scientist after scientist has explained how she was discriminated against. However, most persisted and became scientists. It is helpful for the young scientist-to-be to understand the special kinds of problems other women have faced, and that many young girls in school are facing today.

Education may be a particularly thorny area in which women receive more than their share of discrimination. The experiences of Dr. Elizabeth A. Rauscher, a theoretical nuclear physicist at the Lawrence Berkeley Laboratory of the University of California at Berkeley, made this point:

"As a junior in high school, I was told more than once that women couldn't make a career in science. One example of this was when I was 14 years old, visiting the Lawrence Berkeley Laboratory (where she now works) with my parents. The then assistant director got my folks aside and 'kindly' said, 'Discourage her from a science career—women are not accepted in science.'

"Prejudice seemed particularly prevalent in the undergraduate university laboratories, but less so in the lecture classes," Dr. Rauscher explained. "In one undergraduate physics laboratory, as I would go to the storeroom for more equipment, male students, with the teaching assistant's knowledge and consent, would undo my experimental apparatus. I had to keep close watch to prevent sabotage. I also let it be known I

knew what was going on. Nothing more was done to my equipment. In all my undergraduate physics laboratories at the University of California at Berkeley, I was the only woman. In chemistry, where there were more women in the laboratories, there was much more camaraderie and acceptance of women students. "In a graduate seminar on S-matrix theory, again I was the only woman. The professor launched into a tirade about the stupidity of women, saying their brains were smaller than those of men. After about twenty minutes, I said in a loud voice, 'But you use only 30 percent of your brain anyway!' Not a particularly logical answer, but it shut him up.

"I also had many excellent and reasonable professors who were most helpful and encouraging," Dr. Rauscher pointed out.

Sharon K. Brauman, a Senior Research Chemist at Stanford Research Institute, recently described the factors that influenced her choice of career. "I attended girls' schools, twelve years of preparatory school and four years of college. This had many good features: I was able to pursue studies in any field I desired, I was encouraged in the field of my choice, I had many female role models, and there were many other female science majors. I don't recall being individually encouraged so much. Expectations for everyone were high. From high school, everyone went on to college and from college, a large percentage went on to some form of higher or continuing education.

"Probably as a result of attending girls' schools, I was in graduate school before anyone ever challenged me as to what I was doing. Fortunately, by then I had reached an

age where I could handle such an affront without being discouraged. I think postponing such discrimination is probably advantageous."

FINANCIAL AID

The cost of college today ranges from free tuition at some state colleges to over $6,000 a year at some private schools. When room, board, and other personal expenses are added in, costs at some schools may easily run over $10,000 a year.

Thus, in order to attend the college of your choice, some financial aid may be needed. It is wise to prepare for financing college quite early. Some thorough scouting around on your part may result in your discovering unexpected sources of funding for your particular area of interest.

It is wise to remember that, although you may be admitted to the college of your choice, you may not be given all the financial aid you need to attend the school. Admission and financial aid are granted separately. One does not imply the other.

The federal government offers some educational loan and grant programs. Information about these programs is generally available from the college of your choice or from the U.S. Office of Education, Washington, D.C.

Most schools also offer some type of financial aid and employ financial aid officers to help you arrange the financing of your education. You might also consider working during the school year or during summers to help defray costs. Or perhaps for some it would be better to get a loan and get through school sooner, and then get a better job and pay off the loan.

Women have traditionally been reluctant to go into debt. This fear of going into debt may hinder a woman's full career development. For it stands to reason that if she can not pay for her education, she cannot get it.

In addition to the financial aid opportunities offered through colleges and universities, a number of groups offer special scholarships, grants, loans at low interest, or work opportunities for women. Minority women should also contact the groups that serve their ethnic or racial groups. Many professional societies offer special scholarships and financial aid to minorities. A useful list of financial aid sources for which you might qualify is contained in *Scholarships, Fellowships, and Loans*, by Dr. S. Norman Feingold and Marie Feingold, published in 1977 by Bellman Publishing Co., Arlington, MA. It should be available in most libraries.

The Project on the Status and Education of Women of the Association of American Colleges, 1818 R Street, N.W., Washington, D.C. 20009, also offers a free listing of financial aid opportunities for women.

Be sure you look into unusual sources of financial assistance such as professional or trade groups in the field you are considering. Sororities or work groups to which your parents belong often offer scholarships or financial assistance. Women's organizations, including some of those listed in the Appendix of this book, also offer financial aid to women. Large employers may offer financial aid to promising science students. Sometimes groups may only aid advanced students engaged in graduate studies. Be sure you check this all out ahead of time and get your application for financial assistance in to the proper authorities on time. Late applications generally do not receive financial consideration.

Investigation and persistence often reap big payoffs. Not only may your research net you the money or aid your need to finance your schooling, but it may put you in touch with those professional associations that can help you find a full-time job after you graduate.

Some large employers also offer financial aid. For example, Bell Laboratories offers a graduate research program for women graduate students in physics, mathematics, chemistry, engineering, materials sciences, economics, computer sciences, operations research, and experimental human psychology. Besides the fellowship, summer work is available at the Bell Laboratories under the guidance of research scientists in your field of interest, and many times there is an opportunity for continued employment after your education is completed. A similar program is also available for minorities. Minority women can apply under both programs. Information and an application for the women's program is available from: Dr. David W. McCall, Chemical Director, Room 3A–429, Bell Laboratories, 600 Mountain Avenue, Murray Hill, NJ 07974. Information and application for the minority program is available from: Dr. A. A. Penzias, Director, Radio Research Laboratory, Room 3A–431, at the address above.

Another employer that actively seeks women for specialized one-year programs that offer a range of working experiences in technical areas is the Naval Oceans Systems Center in San Diego, CA 92152. This Department of the Navy-run research and development laboratory specializes in ocean technology, undersea surveillance, command control, and communications. Opportunities are open to women and minorities in physics, computer science, mechanical engineering, and electronics.

CHAPTER 9

GETTING A GOOD JOB

Attempting to get a job in a field where there are often more people than jobs can be discouraging, but with persistence and luck a woman can succeed. However, to maximize her chances of landing a job she must be willing to keep her options open both with regard to type of employer and location.

ACADEMIA

In the past, more women have opted for jobs in academia than in industry. However, there are fewer openings in colleges and universities now for both women and men. In colleges many professors have tenure, which means they may not leave their jobs until retirement.

If a woman does get offered a position at a university, she is most likely to be granted a non-affiliated researcher status. This means that though she is hired by the university, she must scour up her own grants and if she can not get outside funding she has no resources (laboratory or equipment with which to work). Even in junior or community colleges there are fewer faculty positions for the same reason. Thus, more people of both sexes are competing for fewer jobs. For women, this has particular significance.

As Dr. Estelle Ramey, professor of Physiology and Biophysics at Georgetown University School of Medicine,

explained at a recent conference on "Why Educate Women as Scientists," "For years Harvard selected some of the most brilliant young women in our society, allowed them to earn doctorates in the sciences, and then ignored them in the job competition....And Harvard is not any different from any other institution. Junior colleges at the status job level are just as hung up on maleness. It is accepted wisdom that testosterone is the take-charge hormone and that estrogens poison the cerebral cortex.

"At Stanford University the number of tenured women is below what it was five years ago and Stanford now has a vigorous program to recruit 'outstanding' women. This is posited on the notion that every tenured member of the Stanford faculty is an Albert Einstein...and that a few are reincarnations of Isaac Newton. Unfortunately, that has not been my experience with Stanford or any other first-class institution of higher learning. Each has a number of very bright productive men, an equal number of damned fools, and a very large contingent of respectable hacks. Now that women are being sought to comply within reason with the law of the land, a few women are receiving requests for curriculum vitae's from many schools and institutes. This small group of women scientists has managed to be productive under acknowledged obstacles. Some always get through. I had an uncle who refused to recognize that there was discrimination against blacks. He used to say, 'Booker T. Washington made it. All it takes is hard work and ability.' Well, it takes a lot more than that if you are a woman in science," Dr. Ramey said.

"Many women scientists report being interviewed for. . . openings and not receiving the jobs because the departmental chairperson had already selected someone else. Frequently, to make it appear that the university is following affirmative action requirements, women will be interviewed but discouraged from taking the job." Such practices are described in *How To Get a Job,* by Women in Cell Biology and by Dr. Ramey. Women in Cell Biology also has available *How To Keep a Job* and *How to Get a Grant.* Both are available for one dollar each. Send your request with a stamped, self-addressed envelope to E. H. Harris, Department of Botany, Duke University, Durham, NC 27706.

Part of the problem is that women generally do not participate in departmental meetings in the same way their male colleagues do. One woman academician reported that when it came time to fill a vacancy in the department, the chairman asked for names of capable people. The males recommended several people whose names the chairman duly noted. When a woman recommended several eminent women in the field, she was grilled about their accomplishments and professional calibre. Despite excellent qualifications (often exceeding those of males in the field) the suggested women were conveniently forgotten. Such situations still occur with regularity, a number of women scientists explained.

Thus, for a woman to be hired she must not only be exeptional, but she must have someone with clout pulling for her. This is why personal contacts and associations can be so important to aspiring women scientists.

Another place where job openings are listed is the *AWIS Newsletter,* published by the Association for Women in Science, 1346 Connecticut Ave., Washington, D.C. 20036.

Other professional associations also list job openings in their field through their newsletters and/or journals. Two other general publications that list openings include *Science* and *BioScience.*

INDUSTRY

While industry over the years has had a very poor record for hiring women, industry on the whole is now doing much better than academia. Yet many women do not even consider a job in industry.

To many scientists, academia offers a stimulating environment where one may pursue theoretical research. Industry and government, however, usually require more emphasis on practical research. Yet since jobs in academia are extremely limited, women should begin to consider careers in industry.

"I know that to many scientists industrial research is a dirty word and those so employed are thought to have sold their souls for the profit motive," Ruth Havemeyer, product development manager of a pharmaceutical company, told a recent conference on women scientists. Dr. Havemeyer was a laboratory scientist before moving into management. "Some detractors contend that in industry you cannot do the research you want or research that is interesting. That just is not so. You may be hired because of your previous research or expertise in a certain field. Obviously, you would continue in that research field. With the variety of projects carried out in any research firm, it is hard to imagine that a scientist—a person with a natural curiosity—would not find a project that is interesting. I assure you that research in industry is as challenging, rewarding, and frustrating as academic research or

teaching. Your research can lead to publications and patents, just as it can in an academic environment. Also, to the best of my knowledge, industry offers comparable pay to men and women," Dr. Havemeyer said.

In the last few years, many women scientists have climbed up the corporate ladder. As an extra benefit, jobs in industry generally pay better than jobs in academia.

Dr. Rita Colwell, a microbiologist whose story we've already read, explained that, "During the late 1950s and early 1960s the professorial research scientist was so glorified that all scientists tried to fit into this mold. Today there is more of an appreciation for scientists who do well in more practical arenas. They are considered no less a scientist or productive citizen. Many scientists have realized that mulling over cosmic questions in academic environment is not for them."

Dr. Theresa F. Schwarzer, of Exxon Production Research Company, offered her comments on how women can succeed in industry: "I personally believe that currently the limits to a woman's advancement will largely be her own limitations. As a matter of fact, there are indications that, particularly in industry, there may be a tendency to develop women too rapidly. This can have deleterious effects: male backlash and, more importantly, an undermining of a woman's self-confidence if she feels she has not earned the advancement on the basis of true ability and merit."

Her suggestions for women trying to enter the power base are particularly useful: "First and foremost, you must be technologically competent. Administrators in industry are developed after demonstrated scientific contribution. However, you must also be verbally articulate, a cooperative worker, organized, able to set priorities and get the job done

efficiently. Exude a sense of super-confidence and a conviction in your decisions.

"Make a positive impression and set career goals early in your career. I have seen people labeled as 'management material' during the employment interview as a result of an initial impression . . . Potential managers, particularly those destined for top levels, are identified almost from the first day of employment. These individuals are specially cultivated and trained by the company . . . early on in their careers. So if you have management aspirations, let your employer know, and then pursue them via your actions. Don't wait to be asked what you want to do.

"Develop an interest in all aspects of your company's concerns. Consciously work at becoming a 'company man,' for you will be expected to put the company's interests ahead of your own and those of other individuals.

"Press for all the special training you can get, even providing your own initiative in seeking outside education. Never refuse a job assignment offered to you, no matter what or where it is. If the company offers it to you, they think you are ready for it. Also, they may be using the offer to test your dedication to corporate interests rather than your own.

"Work at achieving recognition outside of your organization—profession-wide, if possible. This might be difficult in light of restrictions on publishing, but there are ways such as participating in professional society activities. Most companies view this as good public relations for them. Also, external visibility and recognition increases your value to them. . . . It also heightens their awareness that your services may be sought by others and that they need to remain 'competitive' to keep you.

"Do not be reluctant to change employers through any false sense of loyalty if a significant opportunity . . . should present itself. Many people make their greatest quantum leaps in salary and responsibility by switching employers.

"Generally, the fallacies about women not being able to get along either at the peer or superior-subordinate level are falling away. However, this is definitely an area which requires consideration since women often tend, especially when young and inexperienced, to compete intensely with other women. We will have to learn . . . not to work against each other as more of us have to work together," Dr. Schwarzer noted.

With so many people trying to fill a limited number of openings, the better educated usually get the jobs. And since there are more people with Ph.D.'s, than positions requiring such an advanced level of knowledge, employers nowadays can be more choosy in establishing their basic requirements. Thus, people with Ph.D.'s are being hired to fill jobs which used to require only a Master's degree. Likewise, people with a Master's degree are being hired to fill jobs that used to require only a Bachelor's degree. Men with a Bachelor's degree in science generally find some sort of employment. Women at this level are most likely to suffer the highest unemployment rate of any group. This is especially true for women in fields where there is a greater percentage of women, such as biological sciences.

When you apply for a job in the sciences, your résumé is crucial. Working on creating a good résumé is a difficult chore. In larger cities there are some private agencies that specialize in writing résumés. However, writing your own

résumé provides you with the opportunity to assess your own strengths and think about what you would most like to do.

Two important books on the job search that discuss résumé writing include *Who's Hiring Who* and *What Color Is Your Parachute,* both available at bookstores and public libraries. Both are suitable for women scientists who are seeking their first job, a different job, or a re-entry job after being out of the work force for a number of years.

Dr. Helen McCammon, now a science administrator whose story we've already read, is quite interested in women's career development. She has conducted workshops for women in geoscience on job-hunting techniques, in which she tells her audience, "Know yourself and your capabilities. Then learn how to beat the bushes to get the job you want." She herself learned job-hunting techniques from a Bernard Haldane course and believes it was worth the money.

Writing a functional résumé is one of the things she learned. Such a résumé focuses on what the individual is capable of doing rather than on specific job titles and employment dates. This type of résumé is explained in Bernard Haldane's book, *How To Make A Habit Of Success.* There are other books on job hunting that also explain this type of résumé.

Dr. McCammon and several of the other women interviewed for this book believe that a few women are being promoted for the wrong reasons—often for political reasons rather than for competence. Women should accept jobs for which they have the capability and that build on their past experience, not for reasons of tokenism or government quotas. "While I have been asked by many groups to do a variety of things, I believe in being in a job that builds on what I have done in the past. I have been asked to apply for an opening as

a college president and other openings totally unrelated to science. I believe all persons should evaluate what they are good in and like to do . . . and then go into a job only if it meets these criteria.

"People should broaden their backgrounds so they can take advantage of a variety of opportunities. One cannot predict future careers, but one should have a general goal and be prepared to look out for other things, including career changes," Dr. McCammon explained.

RE-ENTERING THE WORKFORCE

Women returning to the scientific workforce after a period of absence face tough going. Science evolves rapidly. Women coming back to scientific work need to brush up on the latest technical knowledge as well as build up their confidence. The National Science Foundation has sponsored several projects for women scientists who want to return to the science after an extended absence.

Women who choose to return to scientific careers are usually well-motivated. Many of them find that despite years of absence from mathematics and structured thinking, they enjoy relearning and catching up. More such re-entry programs are springing up at colleges and universities across the country.

"When a woman has to interrrupt her training, graduate study, or employment, she should talk over future alternatives or avenues of return with an adviser, and ask for letters of

recommendation which may be used when a return is contemplated," suggested Martha S. White in an article in *Science* magazine.[1]

"Women with similar fields of interest can often profit by forming or joining other women in associations which provide professional stimulation and motivation, as well as information and access to new opportunities. Such groups can be particularly effective in assisting women who have temporarily retired to return to or keep up with their field," Ms. White explained. Some of these groups are listed in Appendix A.

"Some women have planned their own transitional re-entry programs. One woman chemist talked to a local college professor and offered to assist him in his laboratory courses during the year in order to bring her knowledge up to date. She proved so capable that he admitted her to advanced seminars, supervised her in tutorial reading, and is now working to retain her in a permanent capacity in the department." Ms. White stated.

[1]White, Martha S. "Psychological and Social Barriers to Women in Science." *Science*, October, 1970.

APPENDIX

ASSOCIATIONS AND COMMITTEES

This information was supplied by Paula Quick Hall and Anne Swartz of the Office of Opportunities in Science of the American Association for the Advancement of Science.

Astronomy

AMERICAN ASTRONOMICAL SOCIETY
211 Fitzgerald Road
Princeton, NJ 08540
Committee on the Status of Women
Dr. Martha H. Liller
Center for Astrophysics
60 Garden Street
Cambridge, MA 02138

Purpose: To update a previous report by the Working Group on the Status of Women and to make recommendations to the Council of the Society on concrete measures that the society can take to improve the status of women in astronomy.

Biological Sciences

AMERICAN ASSOCIATION OF IMMUNOLOGISTS
9650 Rockville Pike
Bethesda, MD 20014
Committee on Women's Affairs
Ms. Blanche Reines
(same address as above)

Purpose: To promote the opportunities of women immunologists in professional positions: in academic institutions, on organizational committees, as chairpersons at meetings, and as editors and reviewers on journal boards.

AMERICAN SOCIETY FOR CELL BIOLOGY
c/o Nancy L. R. Bucher, M.D.
Huntington Laboratories
Massachusetts General Hospital
Boston, MA 02114
Women in Cell Biology
c/o Dr. Elizabeth Harris
Department of Botany
Duke University
Durham, NC 27706

Purpose: To help women achieve equal status in the field of cell biology by aiding them in finding and getting jobs and grants.

Information available: *The Women In Cell Biology Newsletter*—subscription $3 a year for students, $5 for employed, free to unemployed; *How to Get a Job* and *How to Keep a Job*—pamphlets $1 each, include self-addressed stamp envelope.

AMERICAN SOCIETY FOR MICROBIOLOGY
1913 Eye Street, N.W.
Washington, DC 20006
Committee on the Status of Women Microbiologists

Purpose: To alert ASM membership to needed changes in salary, research and consulting opportunities, and awards for

women microbiologists. Information available: committee reports on status of women, biographies, and sources of grant support.

AMERICAN SOCIETY OF BIOLOGICAL CHEMISTS
9650 Rockville Pike
Bethesda, MD 20014
Committee on Equal Opportunities for Women
Dr. Ann E. Kaplan
National Institute of Health, Bldg. 37-3B27
Bethesda, MD 20014

Purpose: To expand career opportunities for women with doctoral degrees in biochemistry through an information network and a registry of positions and consultant requests for women and minority males. Information available: registry for women/minority biomedical scientists.

BIOPHYSICAL SOCIETY
c/o Dr. M. O. Dayhoff
National Biomedical Research Foundation
Georgetown University Medical Center
3900 Reservoir Road, N.W.
Washington, DC 20007
Committee on Professional Opportunities for Women
Dr. Paula T. Beall
Dept. of Pediatrics
Baylor College of Medicine
1200 Moursund
Houston, TX 77030

Purpose: To represent women in the Biophysical Society and further professional goals of women in science. Information available: names, addresses, newsletter.

Chemistry

AMERICAN CHEMICAL SOCIETY
1155 16th Street, N.W.
Washington, DC 20036
Women Chemists Committee
Ms. Ann E. Donahue, Staff Liaison
(same address as above)

Purpose: To address all professional aspects of the women members of the American Chemical Society. Information available: semi-annual newsletter; *Women on College Chemistry Faculties.*

AMERICAN INSTITUTE OF CHEMISTS
7315 Wisconsin Avenue
Bethesda, MD 20014
Professional Opportunities for Women Committee
Dr. Helene N. Guttman
6306 Bradley Boulevard
Bethesda, MD 20014

Purpose: To establish liaison with other professional groups through affiliation with the Federation of Organizations for Professional Women; to facilitate exchange of job information with other organizations.

Economics

AMERICAN ECONOMIC ASSOCIATION
1313 Twenty-First Avenue, South
Nashville, TN 37212
Committee on the Status of Women in the Economic Profession
Dr. Ann Friedlaender
Department of Economics
Massachusetts Institute of Technology
Cambridge, MA 02139

Purpose: To enhance the workings of the academic labor market; to increase the participation of women in the economics profession; to monitor the status of women in the economics profession. Information available: an annual report published in the *Papers and Proceedings* of the AEA and a triannual newsletter.

Energy

ATOMIC INDUSTRIAL FORUM, INC.
7101 Wisconsin Avenue, N.W.
Washington, DC 20014
Nuclear Energy Women
Ms. Angeline S. Howard
Energy Information
Duke Power Company
P.O. Box 33189
Charlotte, NC 28242

Purpose: To provide energy information to women's groups and others. Information available: speakers, slide programs, literature.

Geology

AMERICAN GEOLOGICAL INSTITUTE
5205 Leesburg Pike
Falls Church, VA 22041
Women Geoscientists Committee
Dr. Mary E. Hileman,
Texaco, Inc.,
P.O. Box 3109
Midland, TX 79701

Purpose: To encourage the participation of women in geosciences and to monitor the status of women in the geoscience profession. Information available: newsletter, career leaflet, roster.

ASSOCIATION OF WOMEN GEOSCIENTISTS
P.O. Box 1005
Menlo Park, CA 94025

Purpose: To encourage the participation of women in the geosciences; to exchange professional and technical information; to improve the professional growth and advancement of women in the geosciences. Membership: persons whose professional activities are in keeping with the Association's

objectives; students in good standing from colleges and universities whose scholastic achievements and interests are in keeping with the Association's objectives. Dues: $10 per year; $3 students; $5 nonmember subscribers. Publications: newsletter.

Mathematics

ASSOCIATION FOR WOMEN IN MATHEMATICS
Center for Research on Women
Wellesley College
828 Washington Street
Wellesley, MA 02181

Purpose: To improve the position of women in mathematics and to encourage women to study and enter careers in mathematics and related fields. Membership: 1,200. Dues: $8 individual; $10 family; $20 institutional; $3 retired or student. Publications: newsletter, five times yearly.

NATIONAL ASSOCIATION OF MATHEMATICS
Dr. Johnny Houston
Department of Mathematics
Atlanta Universtiy
Atlanta, GA 30314

Purpose: To assist persons working in predominantly black colleges and universities with problems common to them. Membership: 200–300; interest in the improvement of mathematics teaching and in the problems of predominantly black colleges and universities. Dues: $5.00 per year. Publications: newsletter, quarterly.

AMERICAN MATHEMATICAL SOCIETY
Committee on Women in Mathematics
Dr. Alice T. Schafer
Department of Mathematics
Wellesley College
Wellesley, MA 02181

Purpose: To encourage and promote the participation of women mathematicians in the mathematical community of the same basis as their male colleagues. Information available: *AMS Notices*, articles on related topics.

Meteorology

AMERICAN METEOROLOGICAL SOCIETY
45 Beacon Street
Boston, MA 02108
Board on Women and Minorities
Dr. Jay Fein
Office of Climate Dynamics
National Science Foundation
Washington, DC 20550

Purpose: To increase the number and participation of women and minorities in the atmospheric sciences. Information available: articles by members of the board; resource list.

Physics

AMERICAN PHYSICAL SOCIETY
335 East 45th Street
New York, NY 10017
Committee on the Status of Women in Physics

Dr. Caroline L. Herzenberg
Applied Physics Division, Bldg. 316
Argonne National Laboratory
Argonne, IL 60439

Purpose: To study the situation of women physicists and make recommendations based on that study. Information available: salary and employment data; "Women in Physics" (a status report); "Roster of Women in Physics" (currently being updated); "A Study of Physics Faculty Members in Two-Year Colleges and Technical Institutes;" A Study of Women High School Physics Teachers;" "Directory of Women Graduate Students in Physics" (periodically updated); "Women in Physics" (career booklet); also, a newsletter (in preparation).

Science

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
1515 Massachusetts Avenue, N.W.
Washington, DC 20005
Committee on Opportunities in Science
Dr. Janet Welsh Brown
Office of Opportunities in Science
American Association for the Advancement of Science
1776 Massachusetts Avenue, N.W.
Washington, DC 20036

Purpose: To enhance the status and accelerate the advancement of women, minorities (including minority women), and handicapped persons in all of the science professions—in academia, government, and industry. Information available:

reports, publications and referral to sources for specific assistance and information on women, minorities, and handicapped persons in science professions.

ASSOCIATION FOR WOMEN IN SCIENCE, INC.
E. Baizer
1346 Connecticut Avenue, N.W., Suite 1122
Washington, DC 20036

Purpose: To further opportunities and career goals for women in science.
Membership: 2,500. Dues: $5–$35 on a sliding scale. Publications: triweekly job bulletin and bimonthly newsletter.

MATH SCIENCE NETWORK
Lenore Blum, Project Director
Director of Collegiate Programs
Mathematics and Computer Science
Mills College
Oakland, CA 94613

Purpose: To promote the participation of women in mathematics and science, and to encourage their entry into nontraditional occupations. Network members have conducted innovative math and science education programs for girls and women and sponsored conferences on the topic. Members also share employment information. A further activity is The Math/Science Resource Network.
Joanne Koltnow, Coordinator
Math Science Resource Center
Mills College
Oakland, CA 94613

NATIONAL INSTITUTE OF SCIENCE
Dr. L. Shelbert Smith
Department of Chemistry
Central State University
Wilberforce, OH 45384

Purpose: To provide a means for the exchange of scientific information, for the exchange of information concerning science education and the improvement of science teaching, and for the presentation of scholarly research papers. Membership: 496 active, 1,170 total; degree from accredited institution in the disciplines of biology, chemistry, mathematics, physics, science education, earth sciences, experimental psychology, and related sciences required; also students in one of the above disciplines. Dues: faculty $8; student $4; associate $25; life $150. Publications: *Transactions* annually; newsletter three times a year.

NATIONAL NETWORK OF MINORITY WOMEN IN SCIENCE
Yolanda Scott George, L-452
University of California
Lawrence Livermore Laboratory
Post Office Box 808
Livermore, CA 94550

Purpose: To communicate, develop, coordinate, and implement projects and programs aimed at changing the patterns of nonparticipation and under-representation of minority women in science. Membership: Open to black, Mexican-American, Asian American, American Indian, and Puerto Rican women

at all levels of training and employment in science engineering occupations, academia, government, industry, or other employment settings. Publications: newsletter.

NATIONAL TECHNICAL ASSOCIATION, INC.
Ms. Sandra A. Jackson
Suite 715, Southern Building
1425 H Street, N.W.
Washington, DC 20005

Purpose: To develop and integrate the minority technical input into the total scientific process, and to bring to minorities an awareness of their technical contribution to the establishment of the world's societies. The objectives are to provide for technical interchange among minorities, disseminate career opportunity information to minorities, to motivate minority youth toward technical careers, and to break down barriers to minorities entering the technical professions. Membership: 7,000 engineers, technologists, and others in associated careers, plus college students in these fields. Dues: $10 per year; $2 per year for students. Publications: quarterly technical journal; monthly newsletter; annual compendium.

SIGMA DELTA EPSILON
GRADUATE WOMEN IN SCIENCE, INC.
1346 Connecticut Avenue, N.W.
Room 1102
Washington, DC 20036

Purpose: To advance the participation and recognition of women in science and to foster research in science through

grants, awards, and fellowships. Membership: 1,500; women holding baccalaureate or higher degree from accredited institutions of higher learning, and engaged in or registered for research in the mathematical, physical, or biological sciences. Dues: $10 full member; $5 student and retired. Publications: *Bulletin* four times yearly.

SOCIETY FOR ADVANCEMENT OF CHICANOS AND NATIVE AMERICANS IN SCIENCE (SACNAS)
P.O. Box 3831
Albuquerque, NM 87192

Purpose: To help increase the representation of Chicanos and American Indians in science; to advocate better opportunities for these minority scientists in all facets of scientific endeavor including research, panel and program reviews, consulting, and administration. Membership: 126; individuals who support objectives of the Society, hold B.S. degrees and practice/teach science. Dues: $25 for regular members; $5 for students. Publications: *SACNAS Newsletter*, bimonthly.

WISE (Women in Science and Engineering)
c/o Dr. Miriam Schweber
22 Turning Hill Road
Lexington, MA 02171

Purpose: To provide mutual support and encouragement among women in science and engineering; to make available to the public information about women scientists; and to provide a contact point for individuals or groups seeking speakers, recruiting, or who for other reasons wish to contact women

scientists and engineers. Membership: 100; professional degree or employment in science or engineering (in the Boston, Massachusetts area) required. Dues: $5 per year. Publications: newsletter, monthly; lists of job openings in New England area.

Statistics

AMERICAN STATISTICAL ASSOCIATION
806 15th Street, N.W.
Washington, DC 20005

Committee on Women in Statistics
Dr. Richard C. Taeuber
Committee on Women in Statistics
American Statistical Association
Office of Technical Support & Statistics, OASPE-HEW
Washington, DC 20201

Purpose: To make ASA members more aware of the common professional interests and problems of the women members of ASA; to promote the status of women in the statistics profession; to encourage women to enter statistics; and to contact and share ideas with other professional groups having similar goals. Information available: journals; annual *Current Index to Statistics;* roster of women; membership survey.

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